

# **Student Drawings and Visual Model-based Reasoning**

Kim Quillin & Stephen Thomas

# Student Drawings and Visual Model-based Reasoning

Kim Quillin & Stephen Thomas



# Minute mystery:

---



# Minute mystery:

---



Starts running SW

# Minute mystery:

---



Starts running SW  
Stops looks around

# Minute mystery:

---



Starts running SW  
Stops looks around  
SE

# Minute mystery:

---



Starts running SW  
Stops looks around  
SE  
Stop & Looks

# Minute mystery:

---



Starts running SW  
Stops looks around  
SE  
Stop & Looks  
NE



# Minute mystery:

---



Starts running SW  
Stops looks around  
SE  
Stop & Looks  
NE  
Stop & Looks

# Minute mystery:

---



Starts running SW  
Stops looks around  
SE  
Stop & Looks  
NE  
Stop & Looks  
NW

# Minute mystery:

---



Starts running SW

Stops looks around

SE

Stop & Looks

NE

Stop & Looks

NW

Heading home and masked man jumps out of no where and takes him out

# Minute mystery:

---



Starts running SW

Stops looks around

SE

Stop & Looks

NE

Stop & Looks

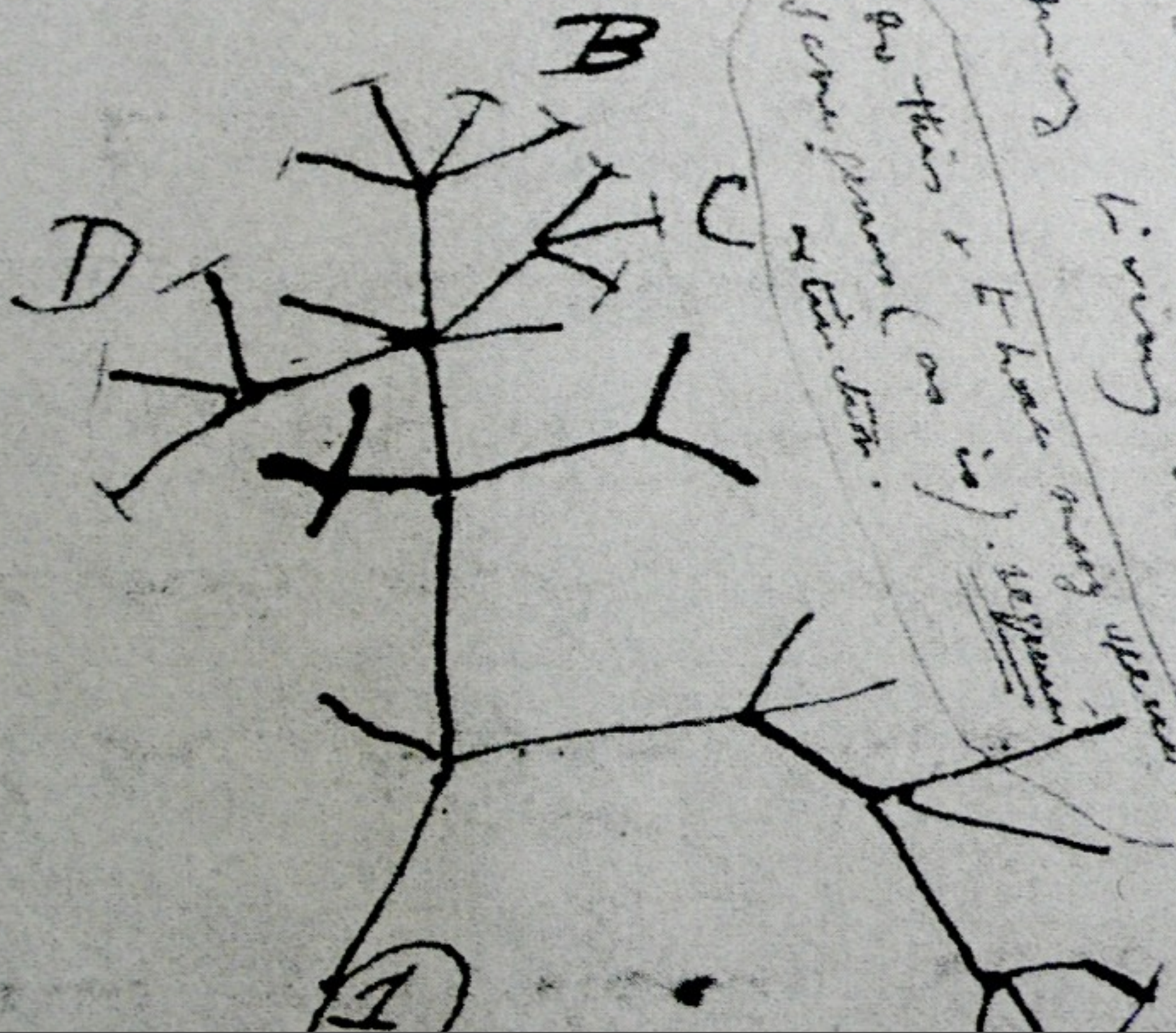
NW

Heading home and masked man jumps out of no where and takes him out





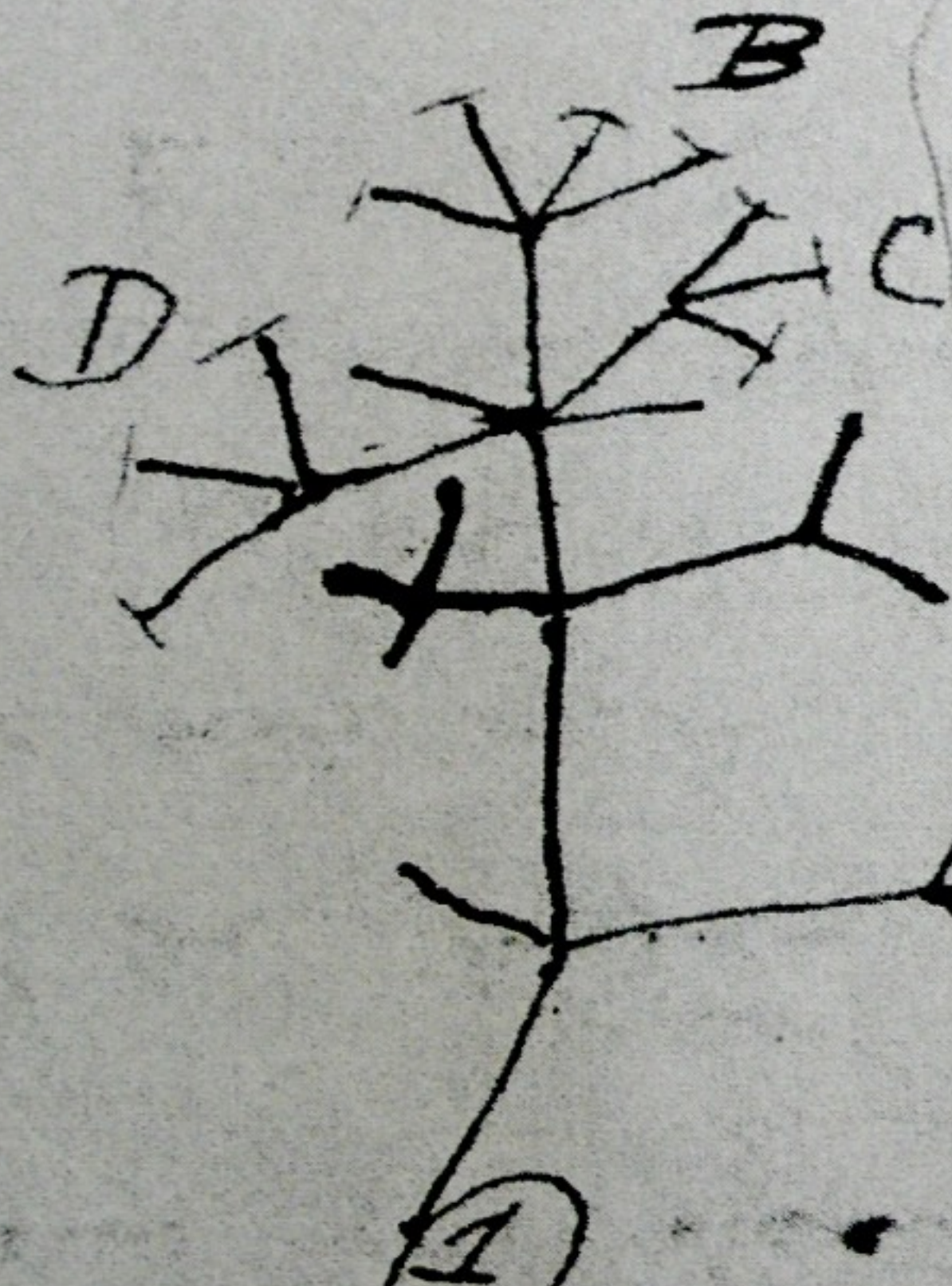
I think



one more E be that one  
 have been there or more  
 living in many species  
 can grow & have many species  
 Do go there & have many species  
 as the last



I think



Do go this & have many specimens  
as far as possible.

can

many

living

as many

should be

that on

Darwin sketch 1836-1837



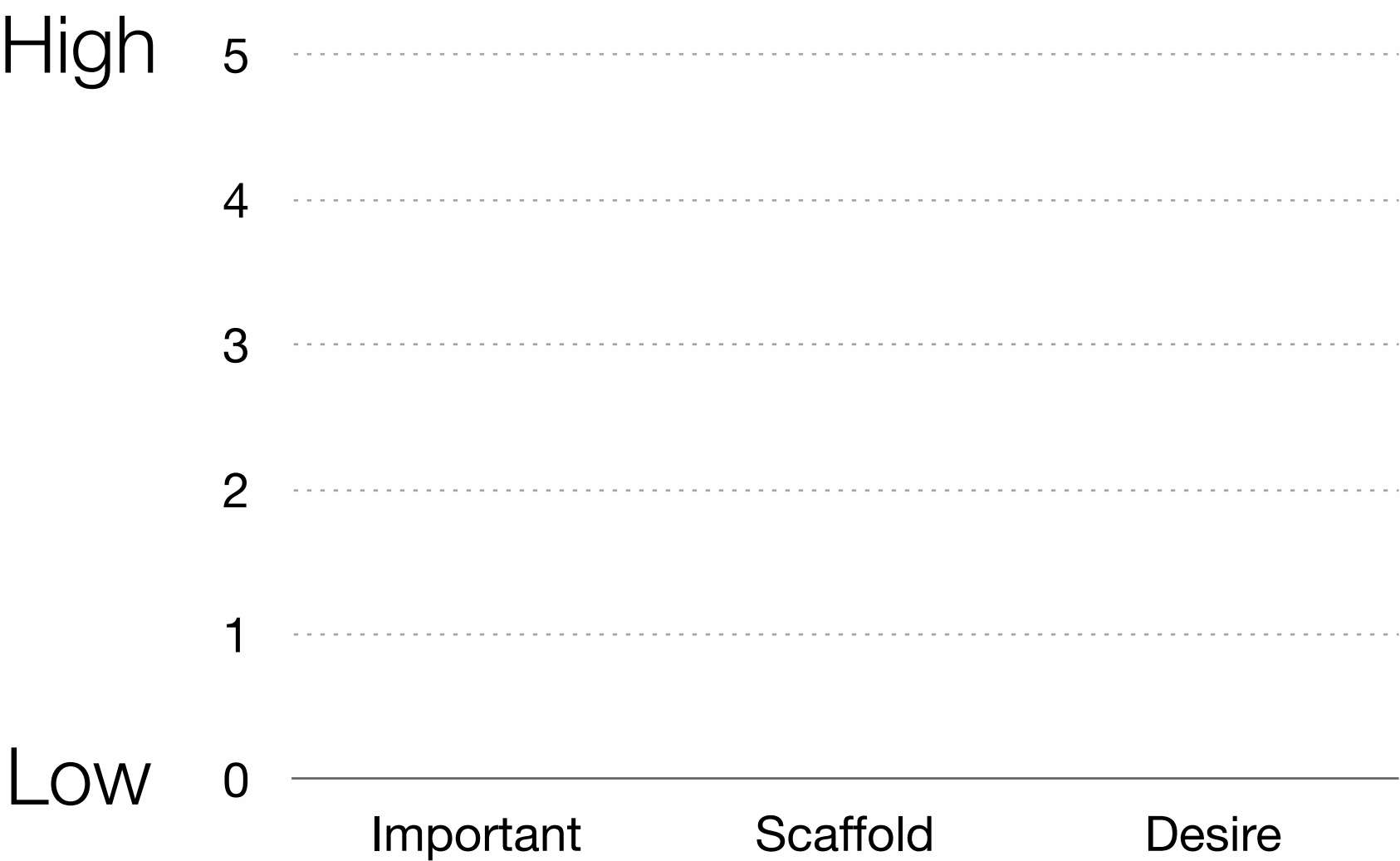
# Data from survey

---



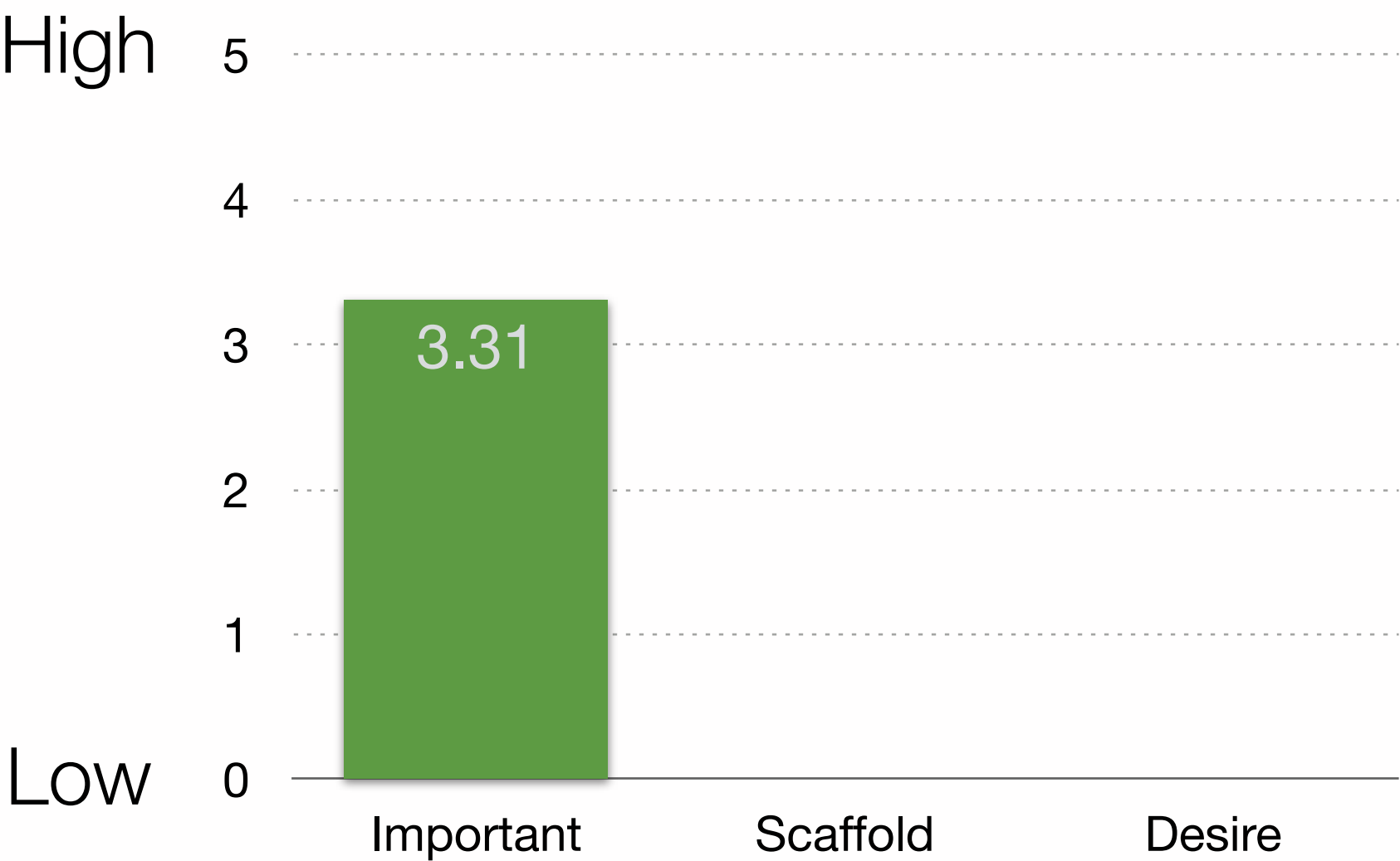
# Data from survey

---



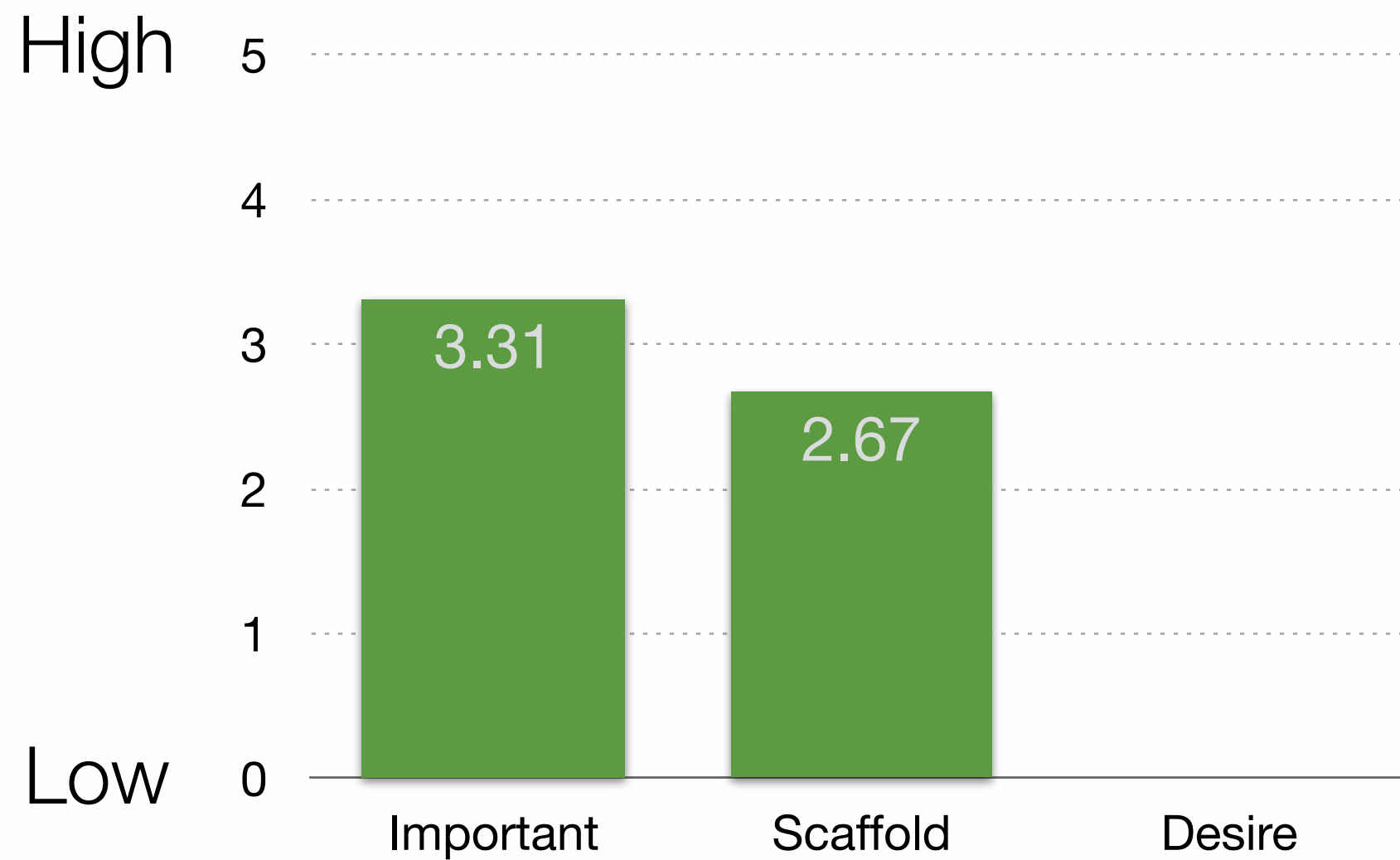
# Data from survey

---



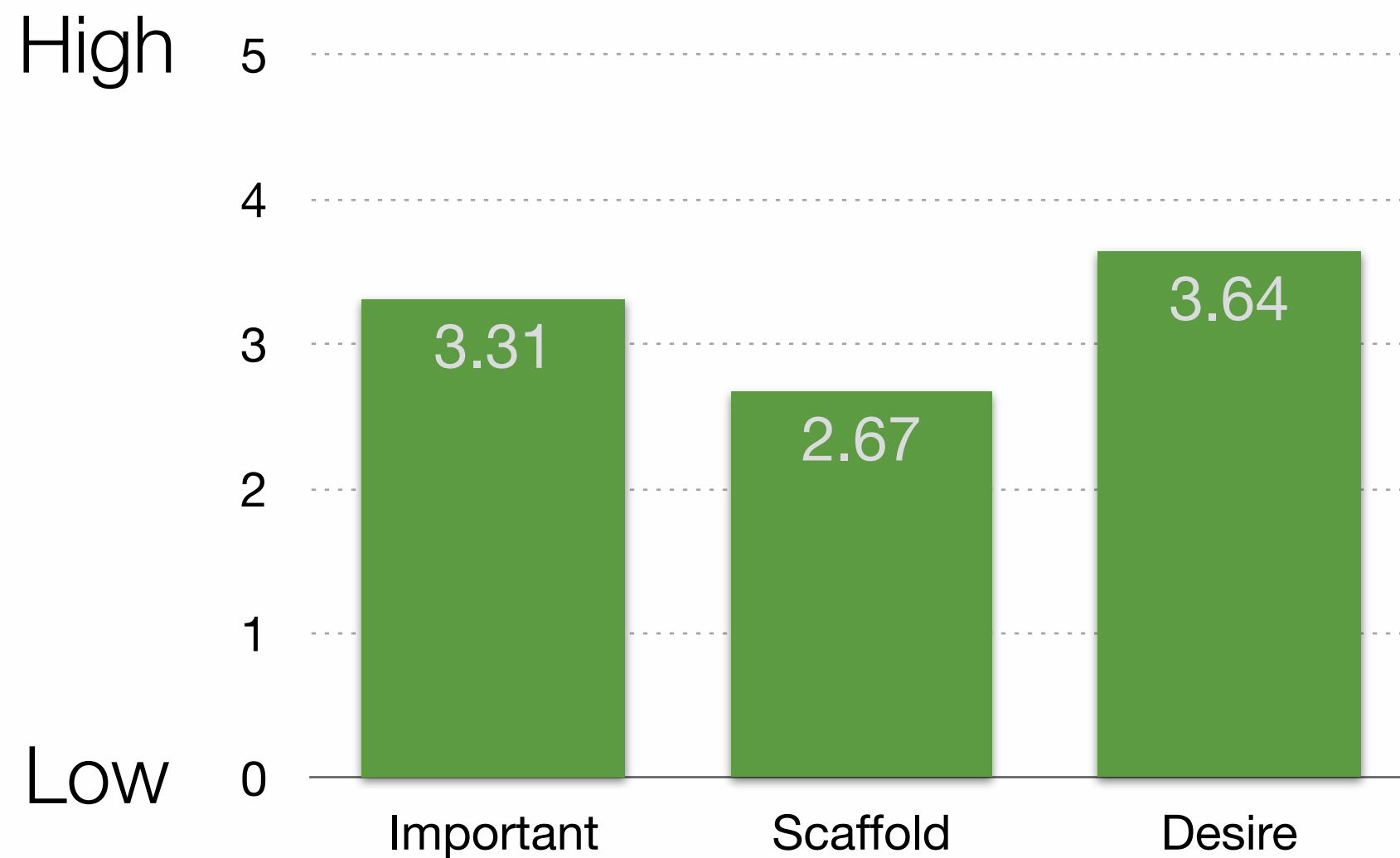
# Data from survey

---



# Data from survey

---



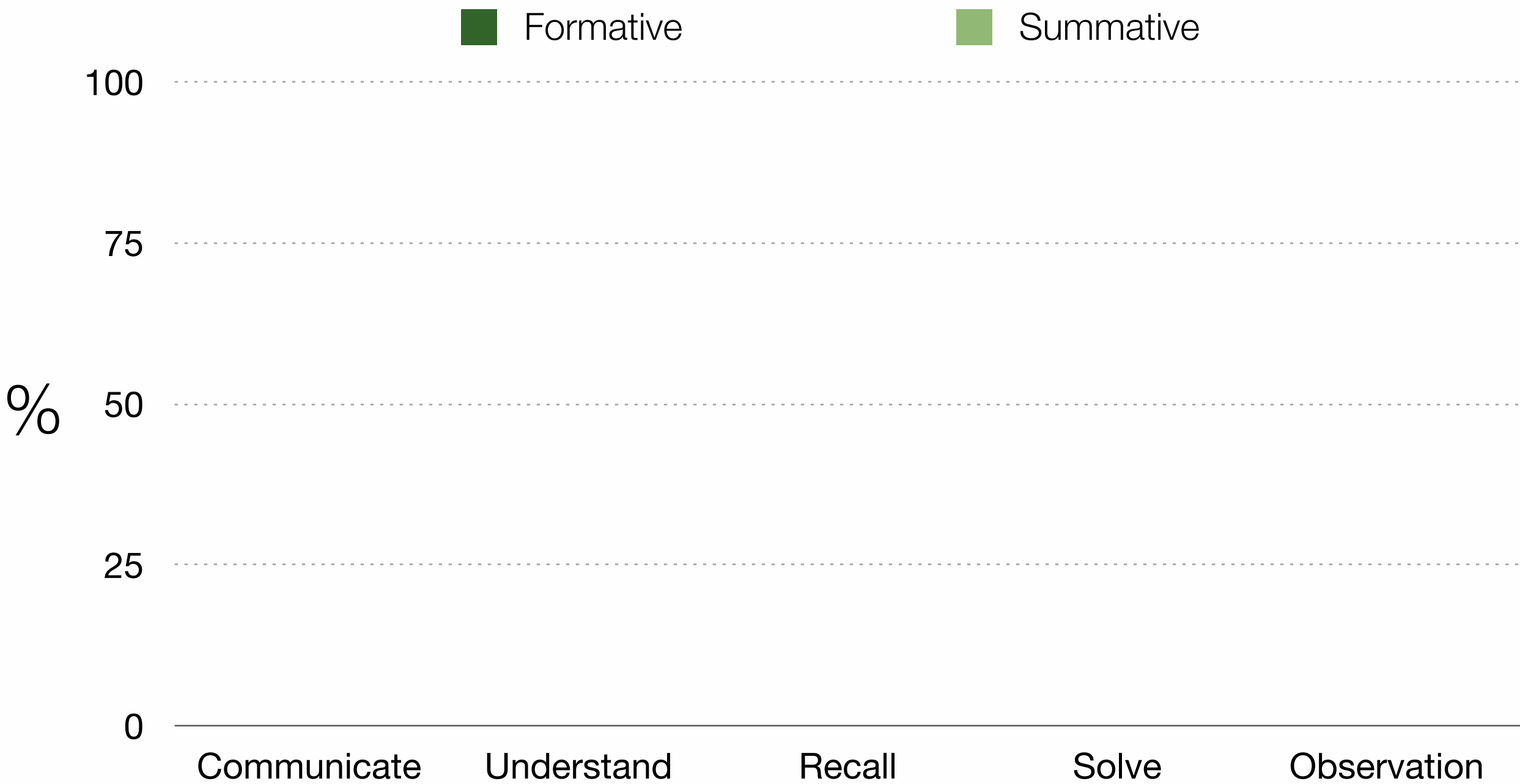
# Data from survey

---

■ Formative

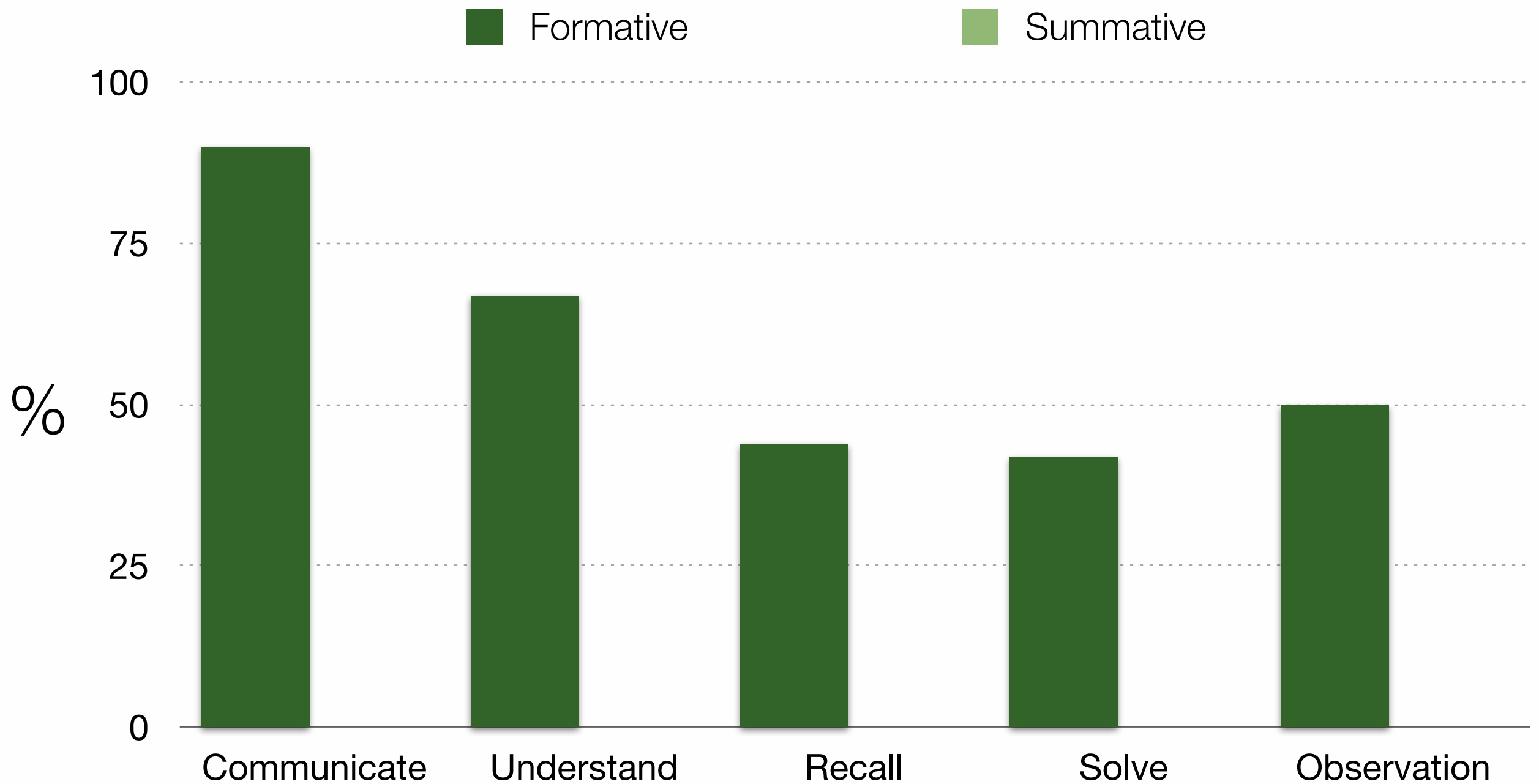
■ Summative

# Data from survey



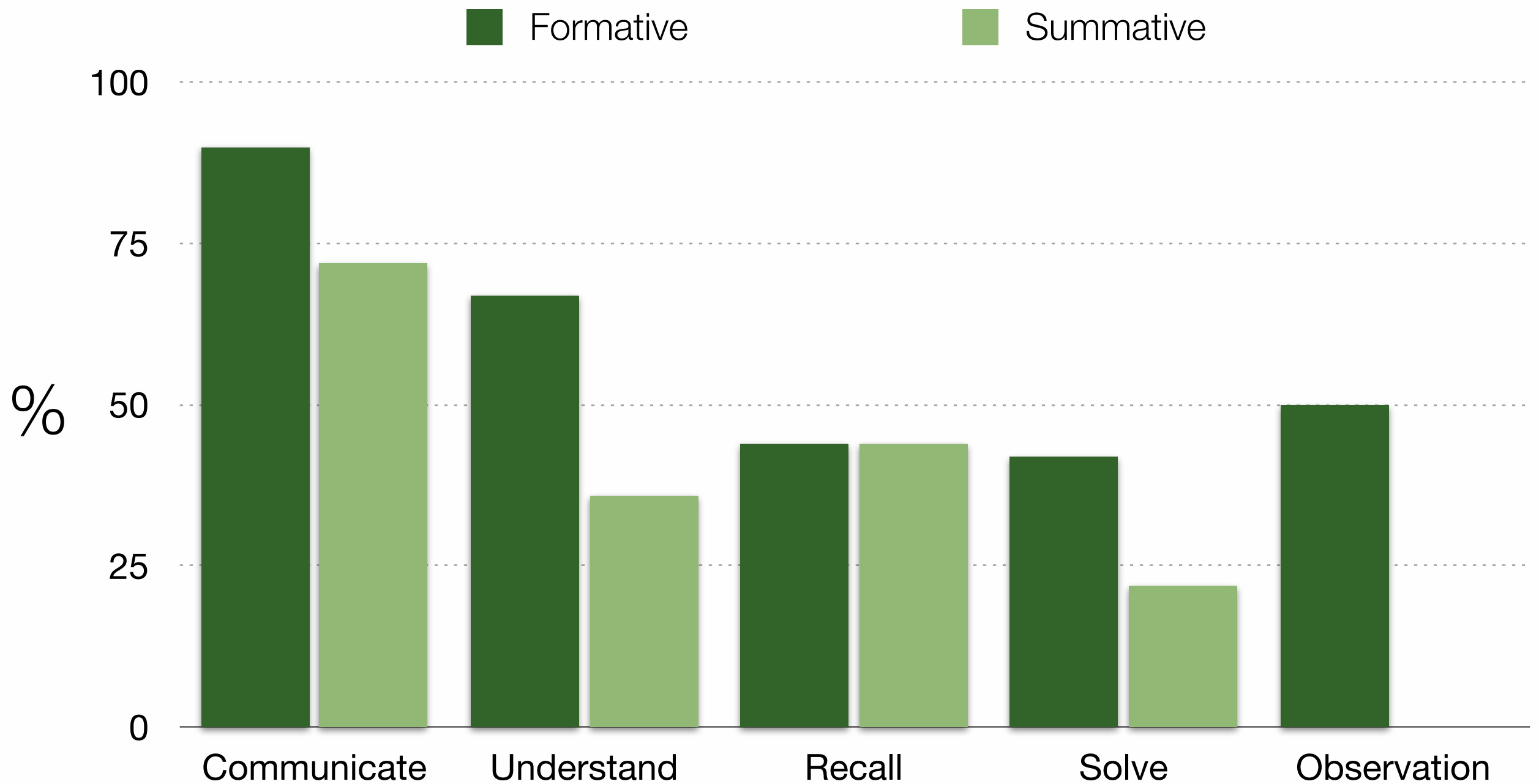
# Data from survey

---



# Data from survey

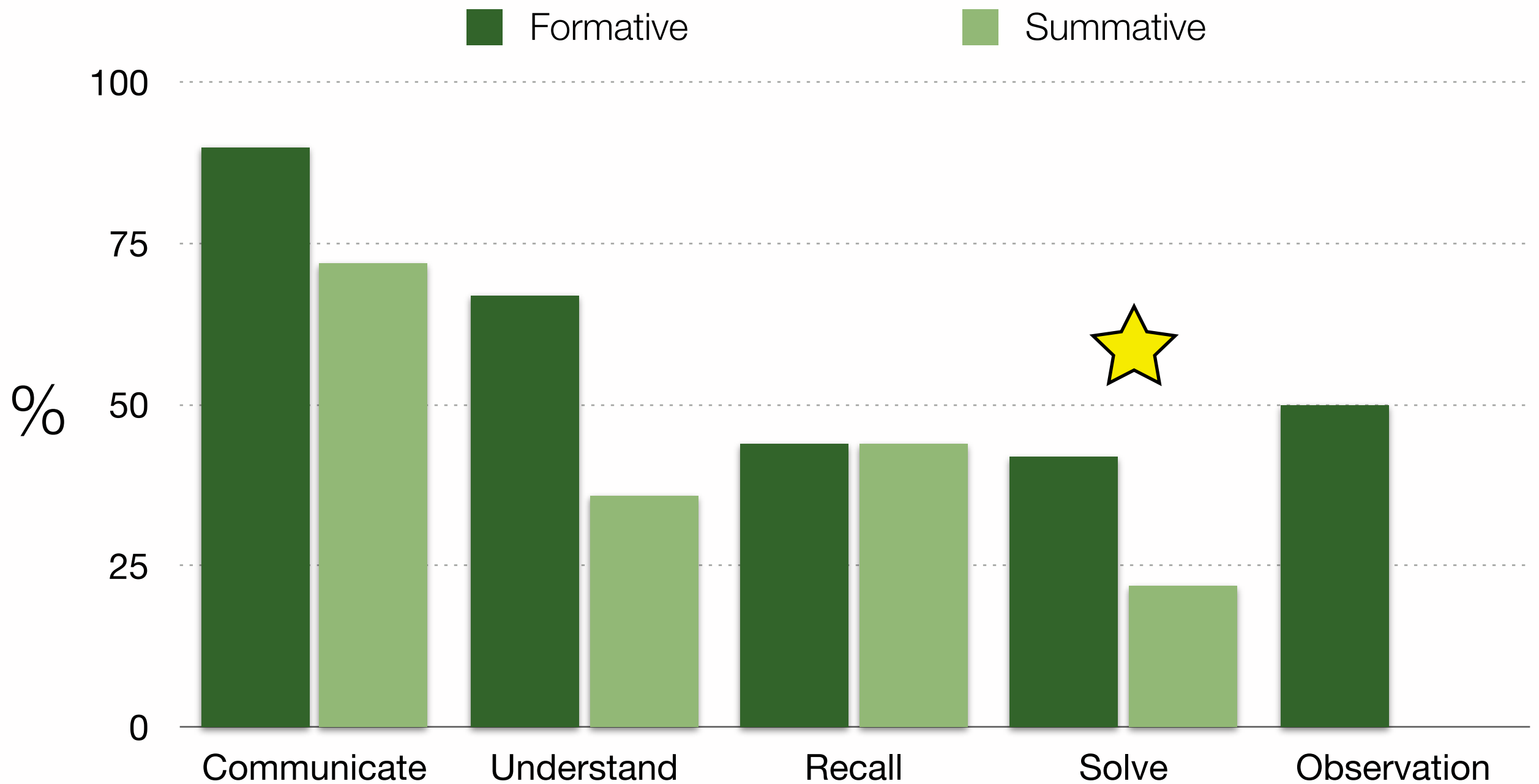
---





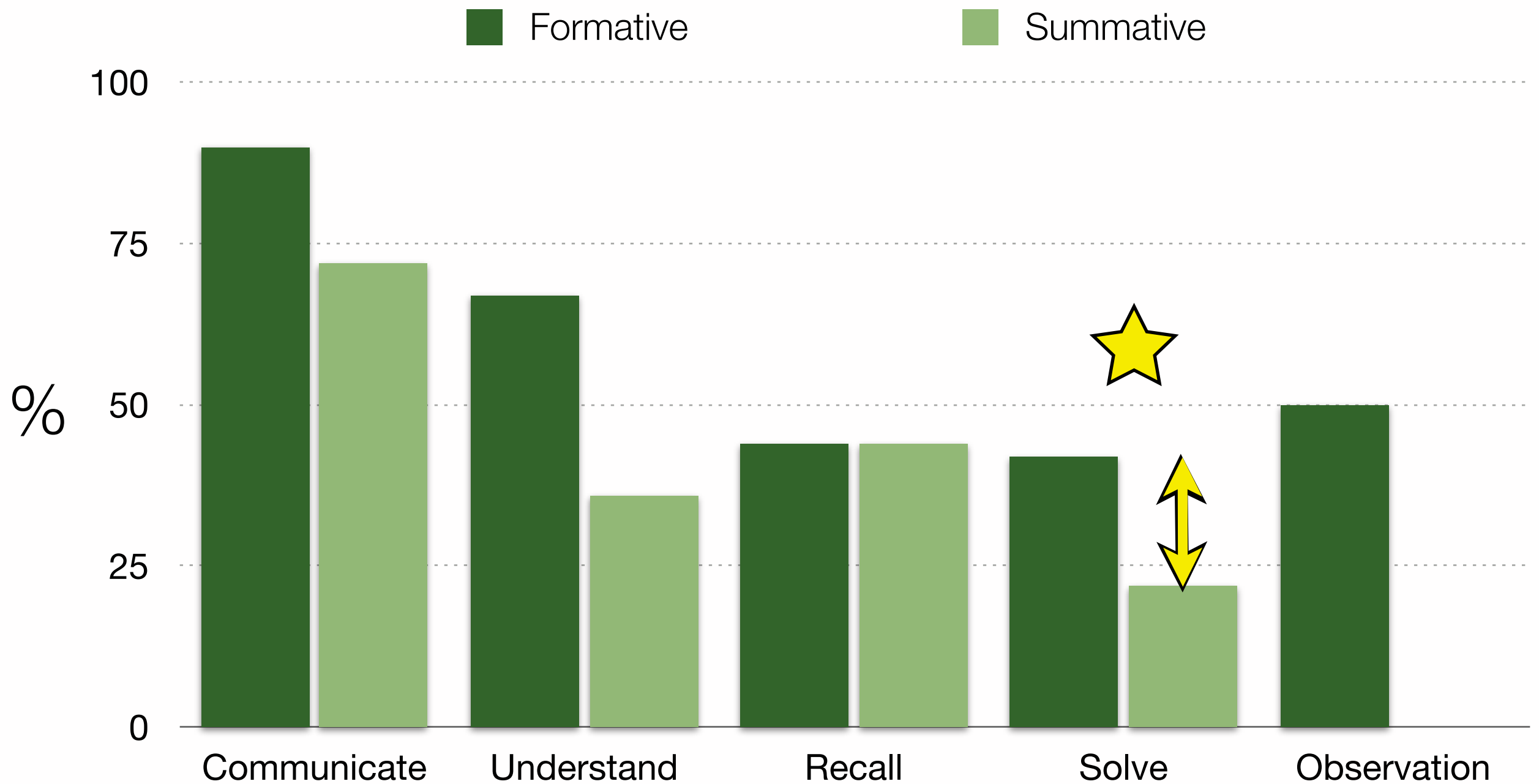
# Data from survey

---



# Data from survey

---



# What is a **student drawing**?

---

# What is a **student drawing**?

---

A learner-generated, external visual representation of an object or idea in static two dimensions.

# What is a **student drawing**?

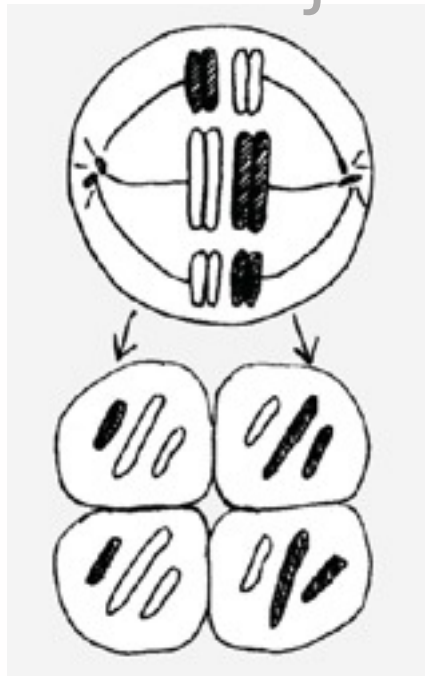
---

A **learner-generated**, external visual representation of an object or idea in static two dimensions.

# What is a **student drawing**?

---

A **learner-generated**, external visual representation of an object or idea in static two dimensions.

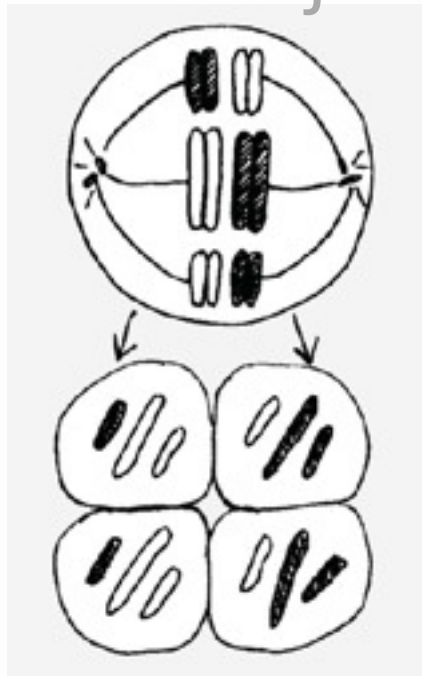


**Instructor-  
generated  
PASSIVE**

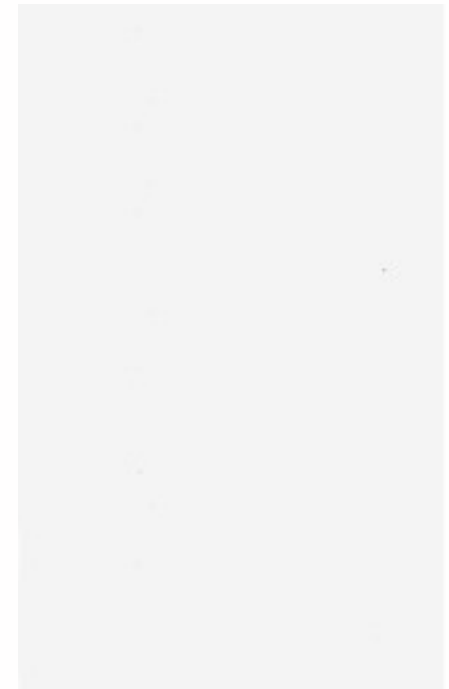
# What is a **student drawing**?

---

A **learner-generated**, external visual representation of an object or idea in static two dimensions.



**Instructor-  
generated**  
**PASSIVE**

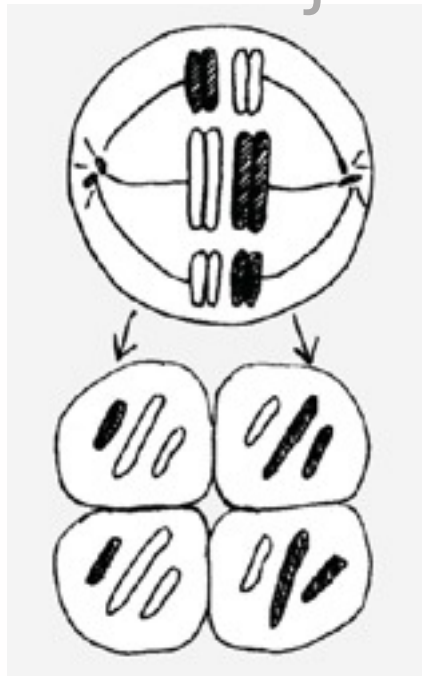


**Learner-  
generated**  
**ACTIVE**

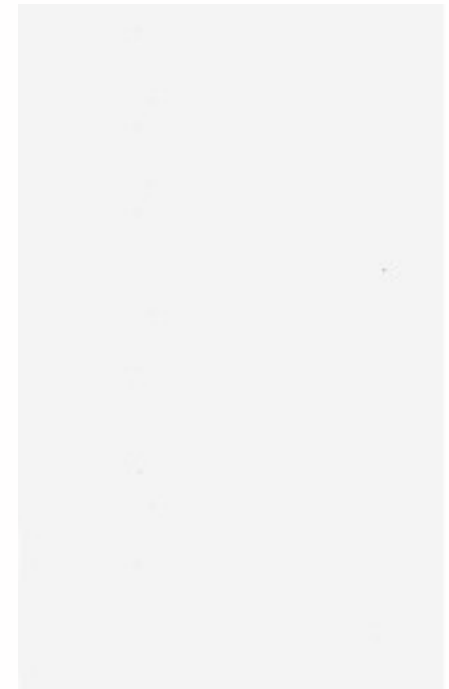
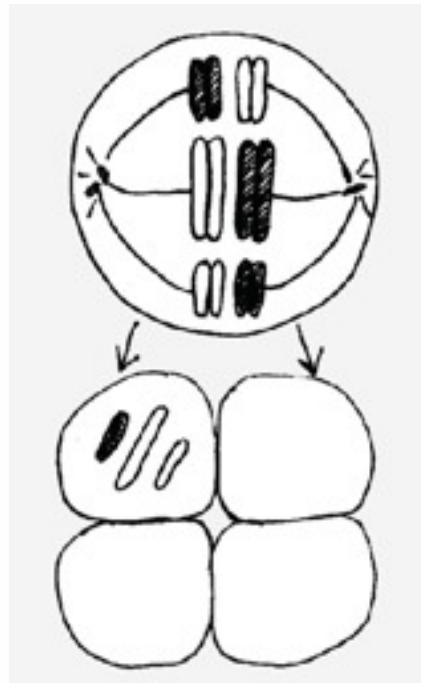
# What is a **student drawing**?

---

A **learner-generated**, external visual representation of an object or idea in static two dimensions.



**Instructor-  
generated**  
**PASSIVE**



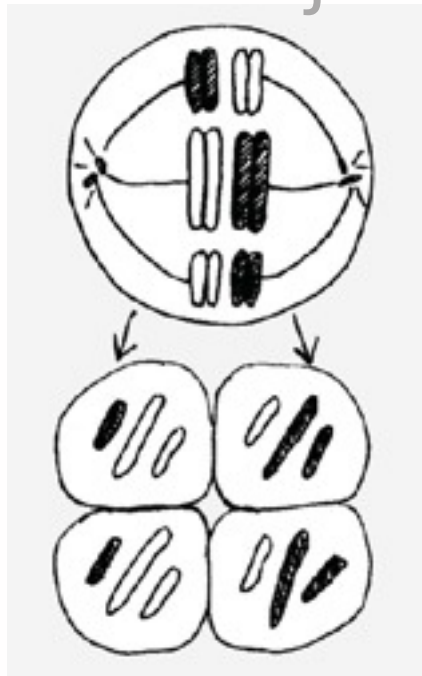
**Learner-  
generated**  
**ACTIVE**



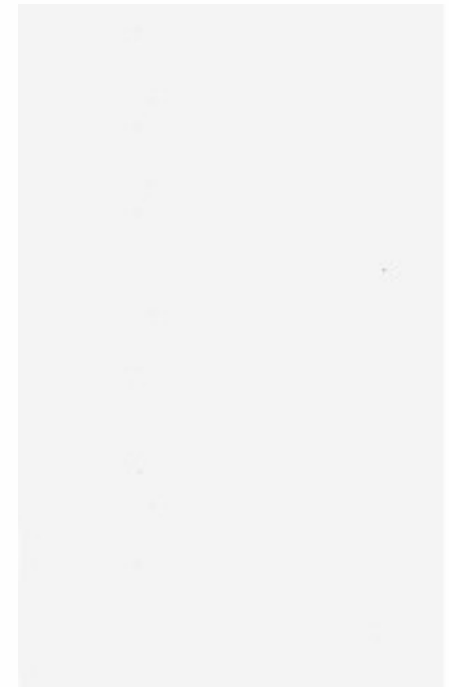
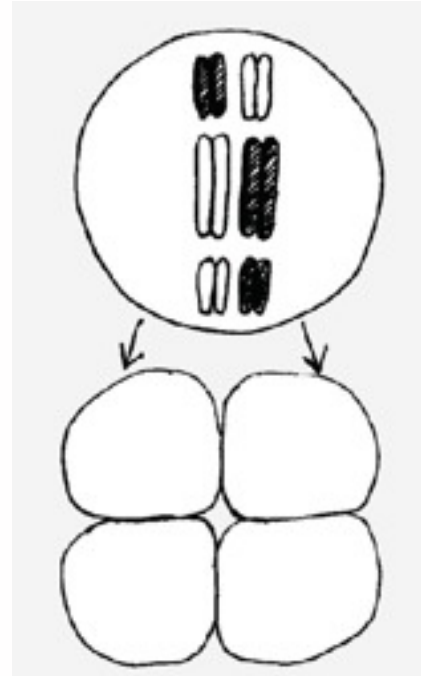
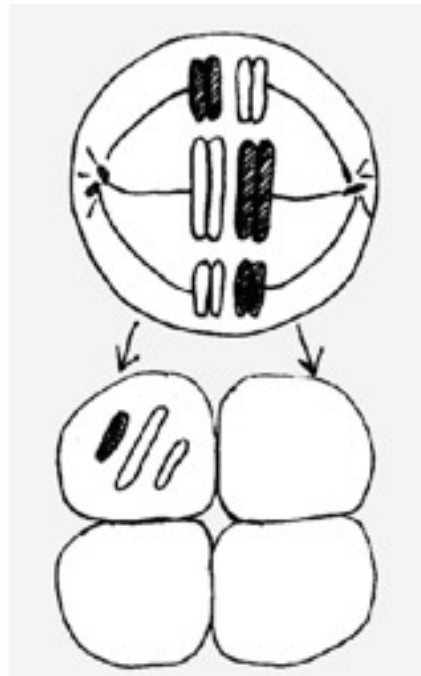
# What is a **student drawing**?

---

A **learner-generated**, external visual representation of an object or idea in static two dimensions.



**Instructor-  
generated**  
**PASSIVE**

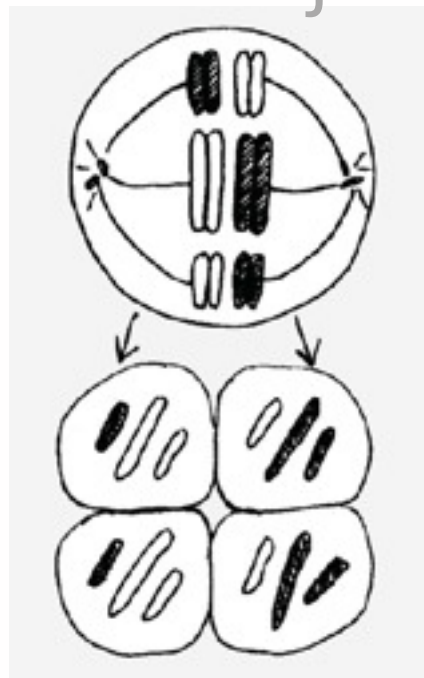


**Learner-  
generated**  
**ACTIVE**

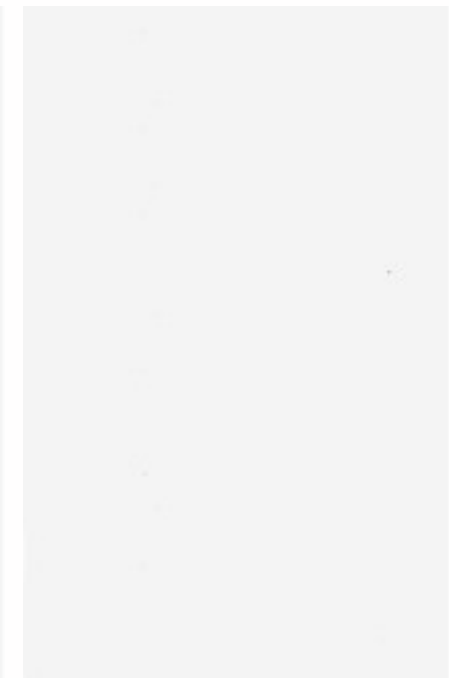
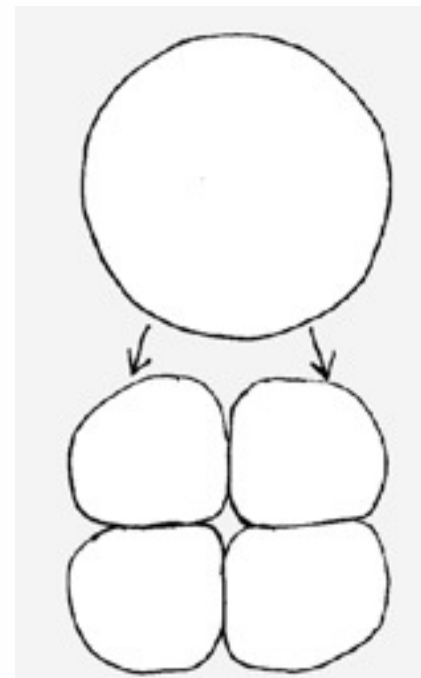
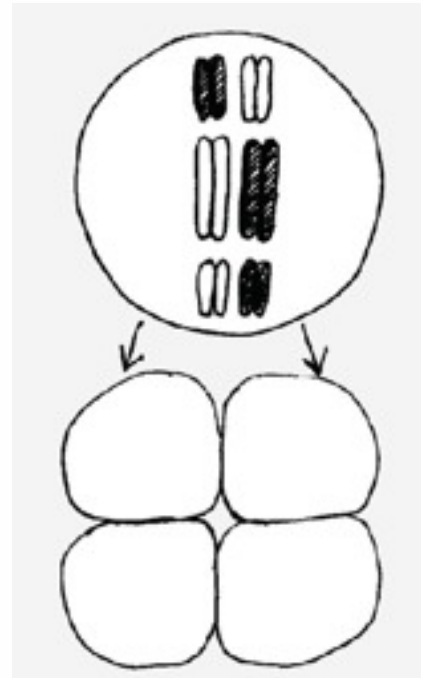
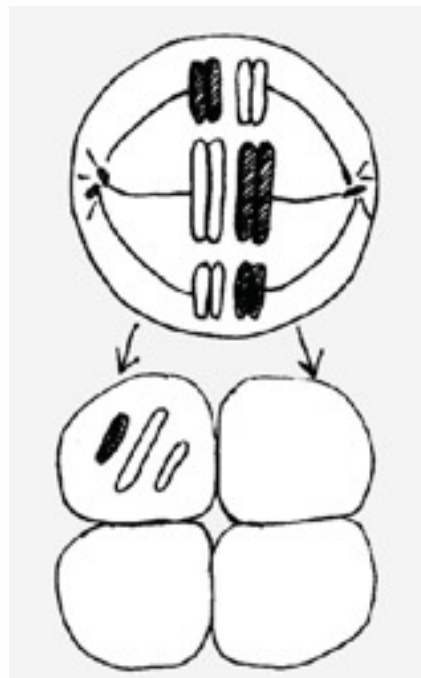
# What is a **student drawing**?

---

A **learner-generated**, external visual representation of an object or idea in static two dimensions.



**Instructor-  
generated**  
**PASSIVE**

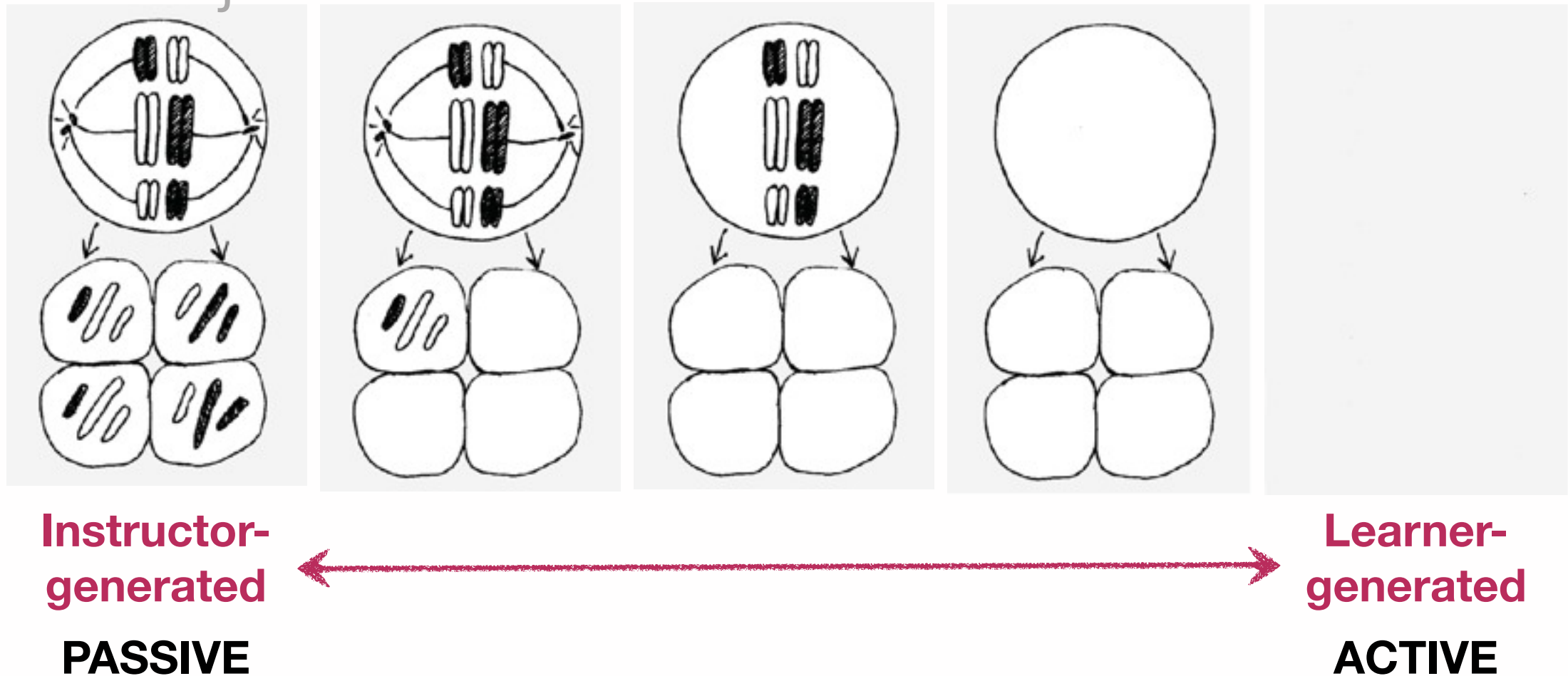


**Learner-  
generated**  
**ACTIVE**

# What is a **student drawing**?

---

A **learner-generated**, external visual representation of an object or idea in static two dimensions.



# What is a **student drawing**?

---

A **learner-generated**, external visual representation of an object or idea in static two dimensions.

# What is a **student drawing**?

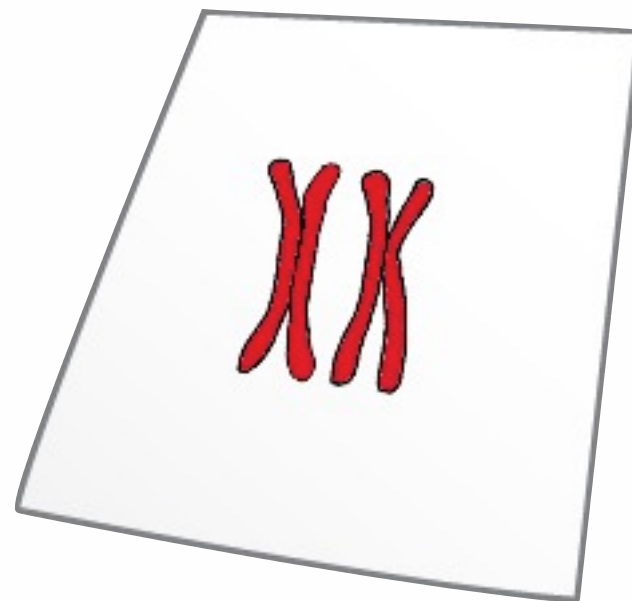
---

A learner-generated, **external visual** representation of an object or idea in static two dimensions.

# What is a **student drawing**?

---

A learner-generated, **external visual** representation of an object or idea in static two dimensions.

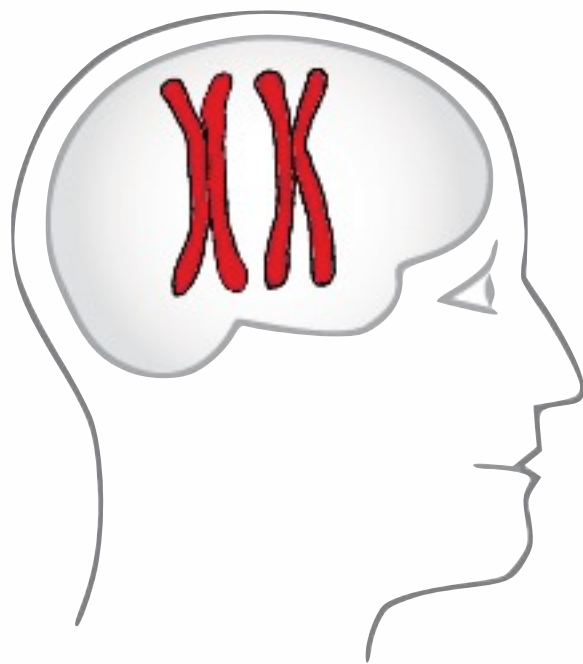


**External  
representation**

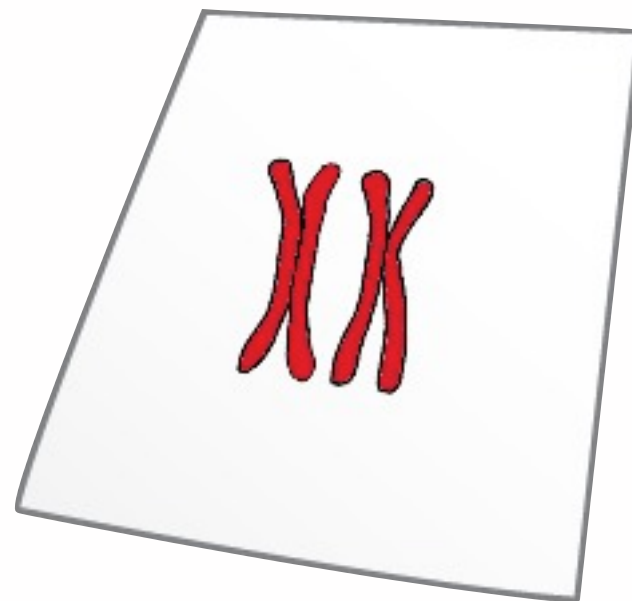
# What is a **student drawing**?

---

A learner-generated, **external visual** representation of an object or idea in static two dimensions.



**Internal model**

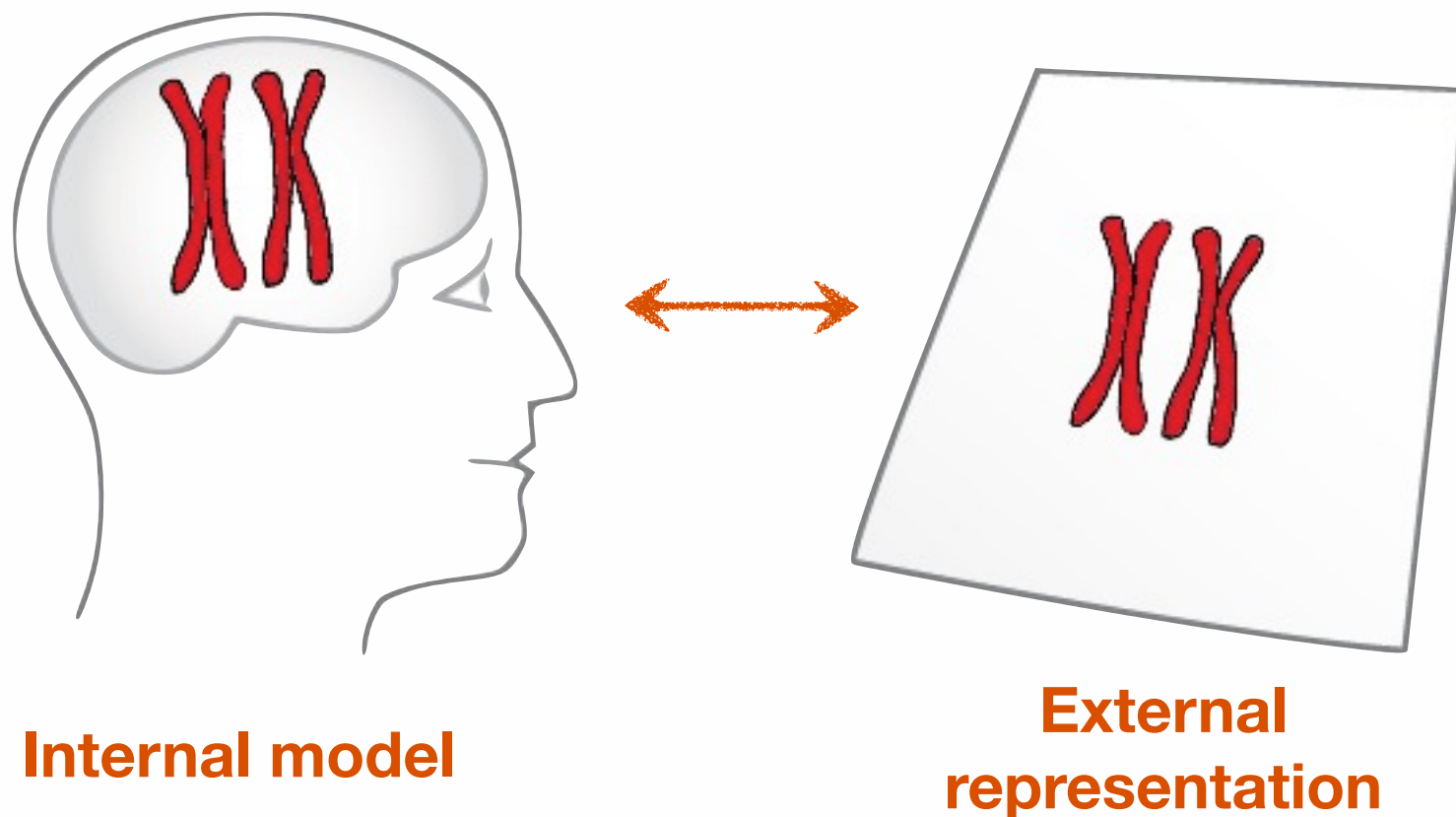


**External  
representation**

# What is a **student drawing**?

---

A learner-generated, **external visual** representation of an object or idea in static two dimensions.





# What is a **student drawing**?

---

A learner-generated, **external visual** representation of an object or idea in static two dimensions.

# What is a **student drawing**?

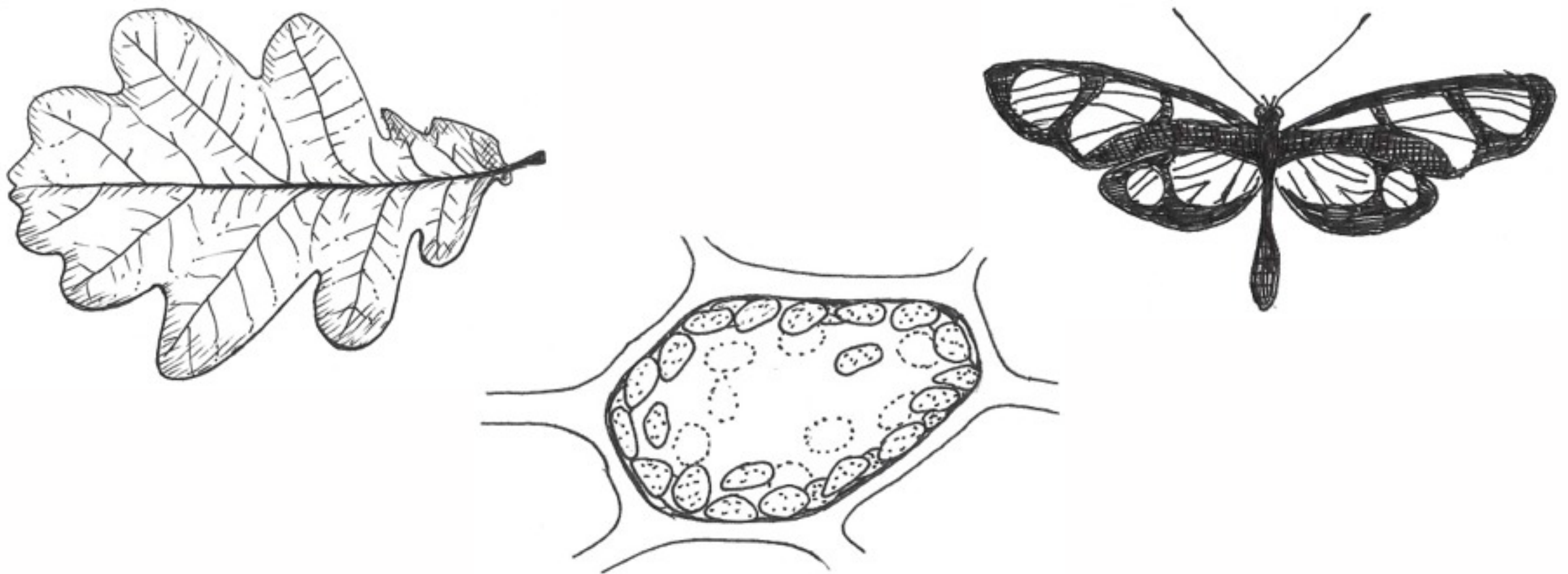
---

A learner-generated, external visual representation of an **object or idea** in static two dimensions.

# What is a **student drawing**?

---

A learner-generated, external visual representation of an **object** or idea in static two dimensions.



# What is a **student drawing**?

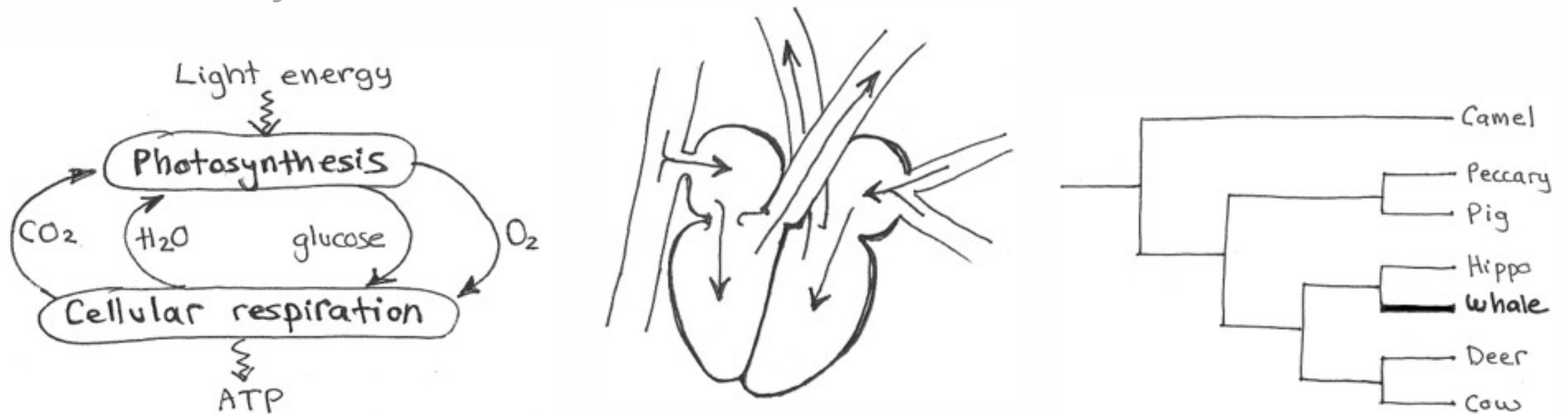
---

A learner-generated, external visual representation of an object or **idea** in static two dimensions.

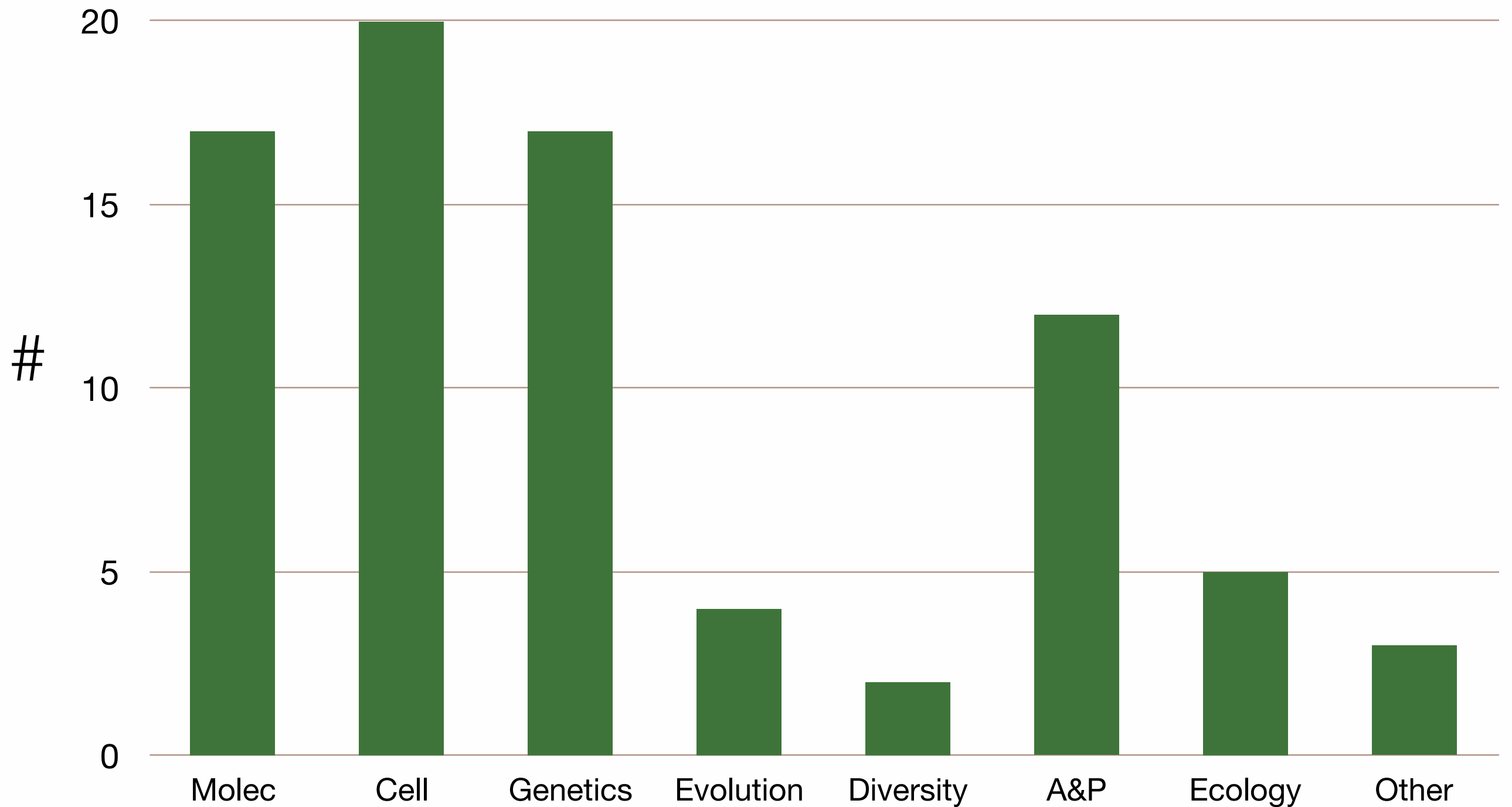
# What is a **student drawing**?

---

A learner-generated, external visual representation of an object or **idea** in static two dimensions.



# Data from survey



# What is a **student drawing**?

---

A learner-generated, external visual representation of an **object or idea** in static two dimensions.



**Representational  
(life-like)**

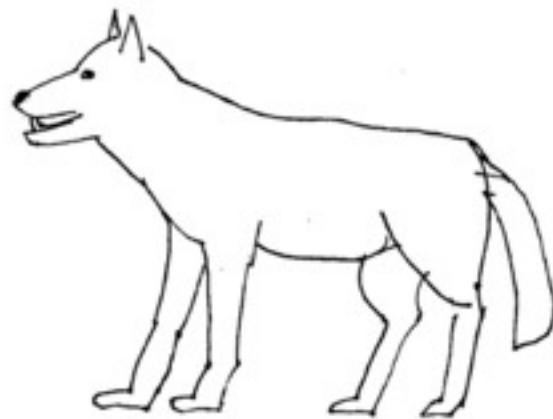
# What is a **student drawing**?

---

A learner-generated, external visual representation of an **object or idea** in static two dimensions.



**Representational  
(life-like)**





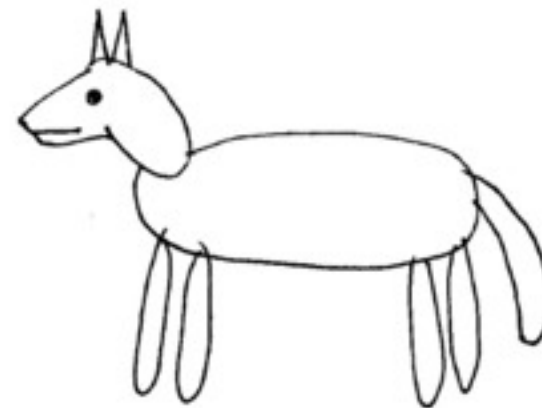
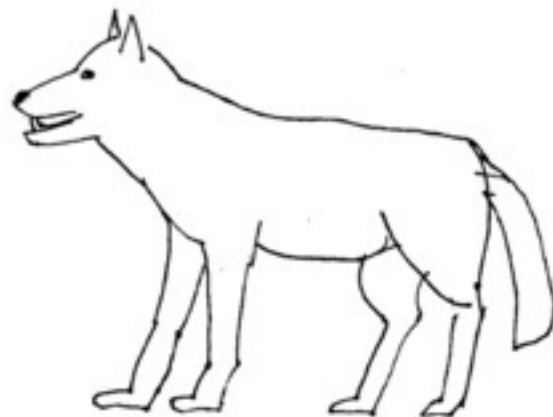
# What is a **student drawing**?

---

A learner-generated, external visual representation of an **object or idea** in static two dimensions.



**Representational  
(life-like)**



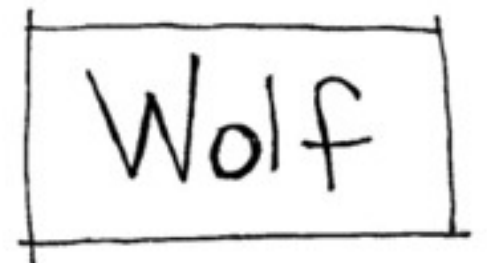
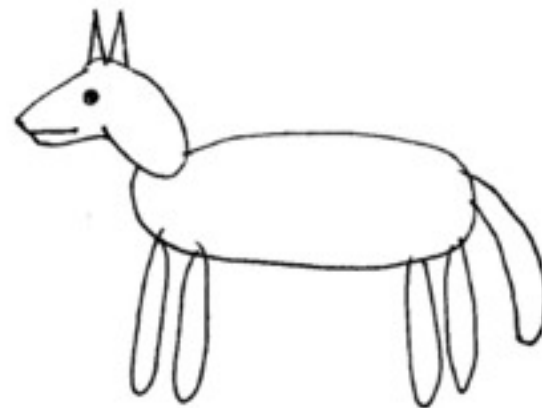
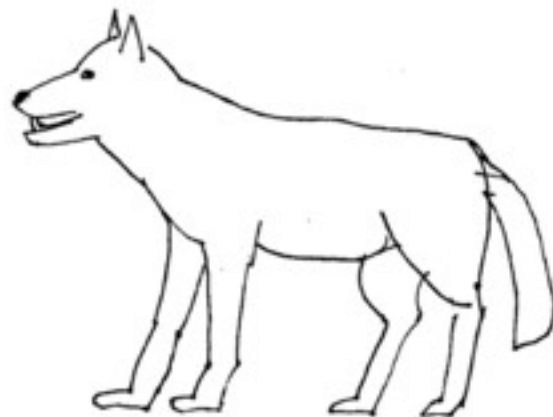
# What is a **student drawing**?

---

A learner-generated, external visual representation of an **object or idea** in static two dimensions.



**Representational**  
**(life-like)**



**Abstract**

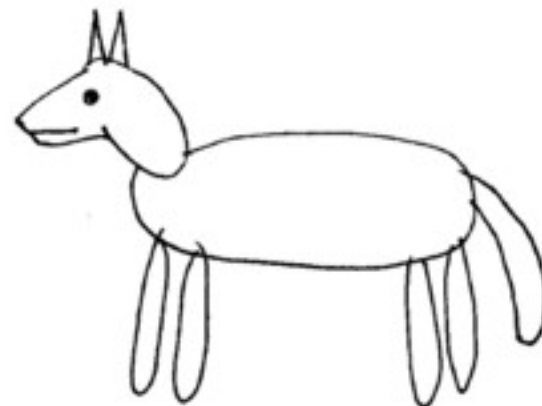
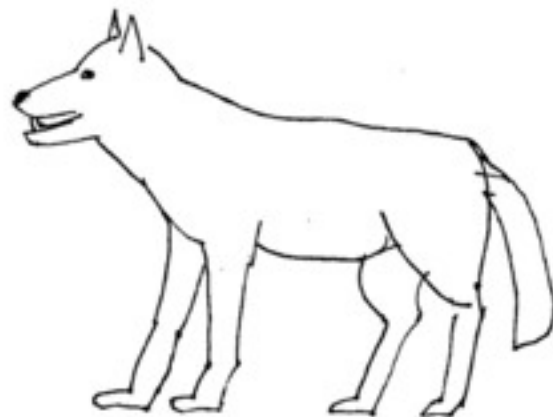
# What is a **student drawing**?

---

A learner-generated, external visual representation of an **object or idea** in static two dimensions.



**Representational**  
(life-like)



**Abstract**



# What is a **student drawing**?

---

A learner-generated, external visual representation of an **object or idea** in static two dimensions.

# What is a **student drawing**?

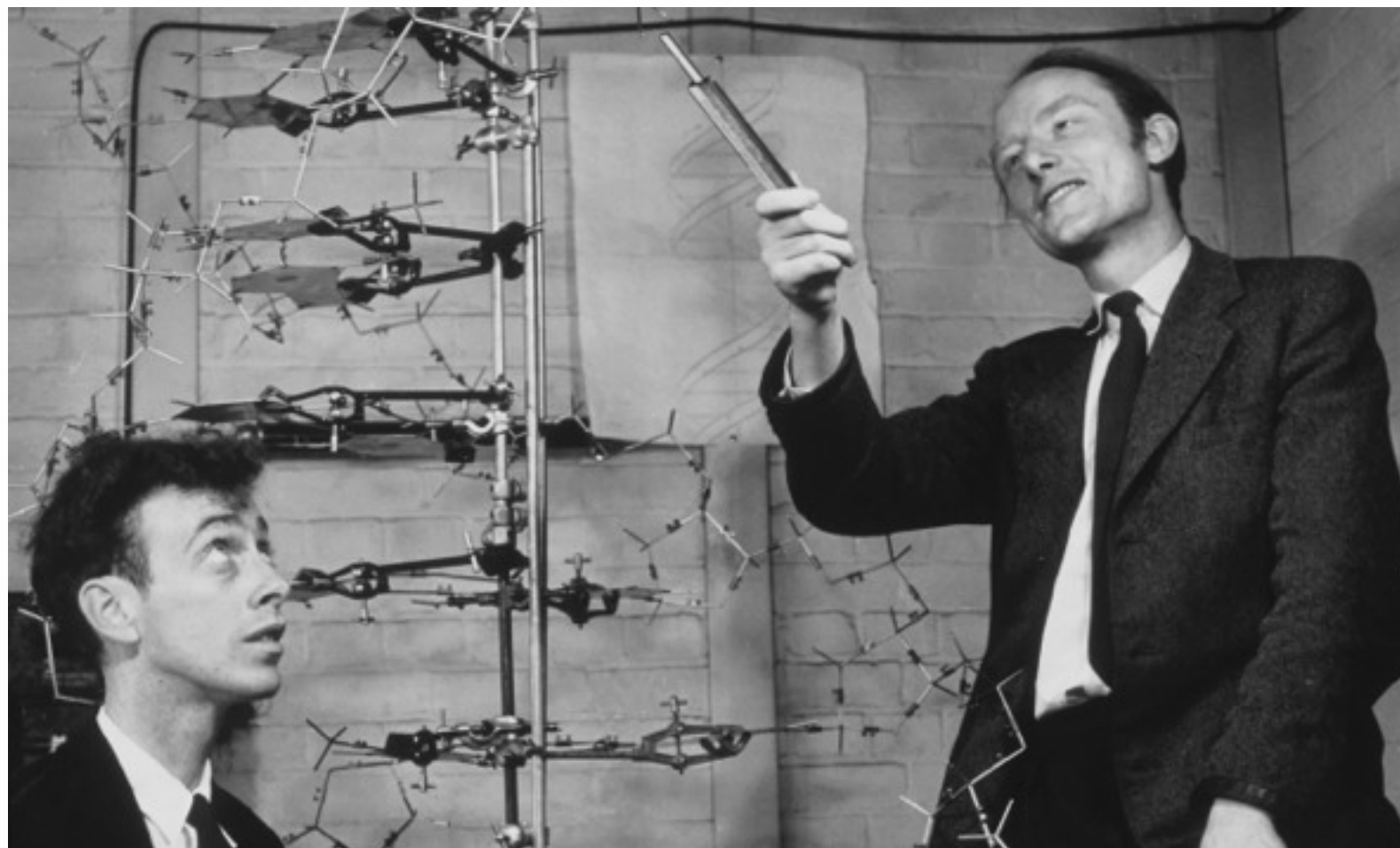
---

A learner-generated, external visual representation of an object or idea in **static two dimensions**.

# What is a **student drawing**?

---

A learner-generated, external visual representation of an object or idea in **static two dimensions**.



# What is a **student drawing**?

---

A learner-generated, external visual representation of an object or idea in static two dimensions,  
**whether on paper, on a white board, or digital.**

# What is a **student drawing**?

---

A learner-generated, external visual representation of an object or idea in static two dimensions,  
**whether on paper, on a white board, or digital.**





# Why ask students to draw?

---

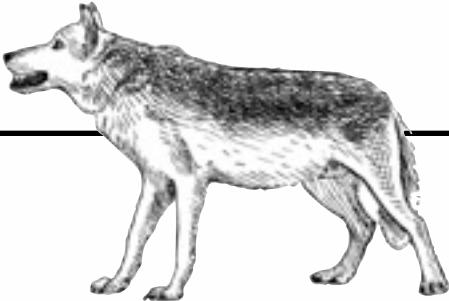

# Why ask students to draw?

---

<b>Formative exercises</b>	
<b>Summative exercises</b>	

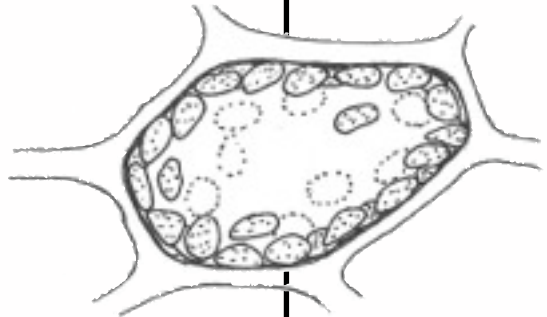
# Why ask students to draw?

---

	Representational drawings	Abstract drawings
Formative exercises		
Summative exercises		

# Why ask students to draw?

---

	Representational drawings	Abstract drawings
Formative exercises	<p>Engage active learning Enhance observation skills Enhance memorization Enhance understanding Improve motivation/affect</p> 	
Summative exercises		

# Why ask students to draw?

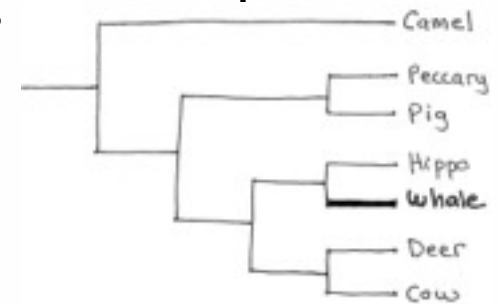
---

	Representational drawings	Abstract drawings
Formative exercises	Engage active learning Enhance observation skills Enhance memorization Enhance understanding Improve motivation/affect	
Summative exercises	Record observations Communicate knowledge	



# Why ask students to draw?

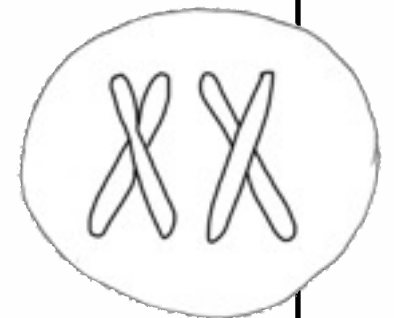
	Representational drawings	Abstract drawings
Formative exercises	Engage active learning Enhance observation skills Enhance memorization Enhance understanding Improve motivation/affect	Engage active learning Foster construction of mental model Foster connection of concepts Reveal misconceptions Promote metacognition Improve motivation/affect Promote interpretation of data Reduce cognitive load
Summative exercises	Record observations Communicate knowledge	



# Why ask students to draw?

---

	Representational drawings	Abstract drawings
Formative exercises	Engage active learning Enhance observation skills Enhance memorization Enhance understanding Improve motivation/affect	Engage active learning Foster construction of mental model Foster connection of concepts Reveal misconceptions Promote metacognition Improve motivation/affect Promote interpretation of data Reduce cognitive load
Summative exercises	Record observations Communicate knowledge	Reveal misconceptions Communicate knowledge Facilitate problem solving



# Why ask students to draw?

---

	Representational drawings	Abstract drawings
Formative exercises	Engage active learning Enhance observation skills Enhance memorization Enhance understanding Improve motivation/affect	<b>Engage active learning</b> <b>Foster construction of mental model</b> <b>Foster connection of concepts</b> <b>Reveal misconceptions</b> <b>Promote metacognition</b> <b>Improve motivation/affect</b> <b>Promote interpretation of data</b> <b>Reduce cognitive load</b>
Summative exercises	Record observations Communicate knowledge	Reveal misconceptions Communicate knowledge Facilitate problem solving



# Why ask students to draw?

---

	Representational drawings	Abstract drawings
Formative exercises	Engage active learning Enhance observation skills Enhance memorization Enhance understanding Improve motivation/affect	<b>Visual model-based reasoning</b>
Summative exercises	Record observations Communicate knowledge	Reveal misconceptions Communicate knowledge Facilitate problem solving

# Model-based reasoning

```
graph TD; A[Model-based reasoning] --> B[Mathematical]; A --> C[Physical]; A --> D[Visual]; A --> E[Dynamic]; A --> F[Verbal];
```

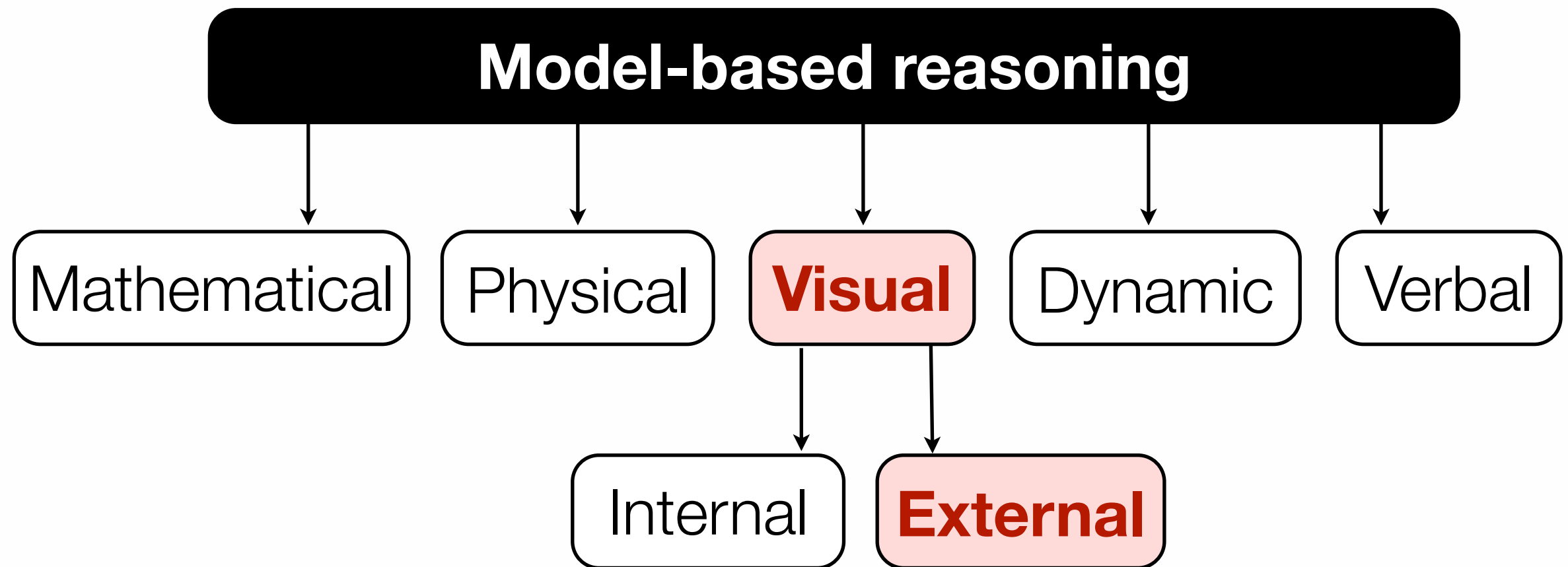
Mathematical

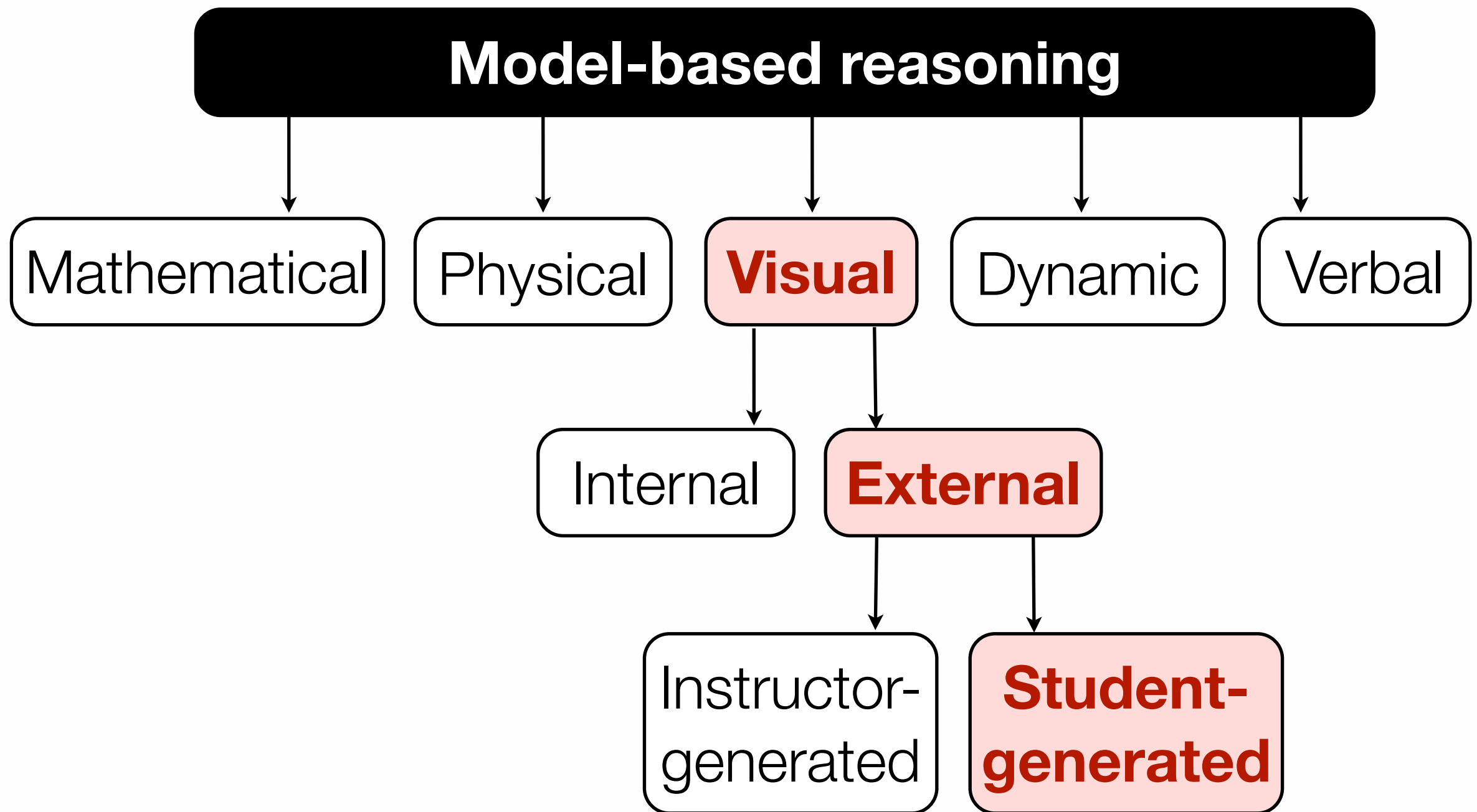
Physical

**Visual**

Dynamic

Verbal





# Breakout...

---

# Developing your Visual Mental Model (internal):

---

In your mind, take a moment to think about how “the greenhouse effect” works.

# Developing your Visual Model (external):

---

Draw a picture that explains  
“the greenhouse effect” on Earth.  
Use labels to explain your diagram.

# Report out . . .

---

How did you represent invisible processes?

What went well?

Were there any barriers to your success?





# Testing your model!

---

Using one of your models,  
answer the following question:

Climate predictions indicate an increase in precipitation at the Earth's north and south poles leading to increased ice coverage and reflection of light. How will this influence atmospheric temperatures?

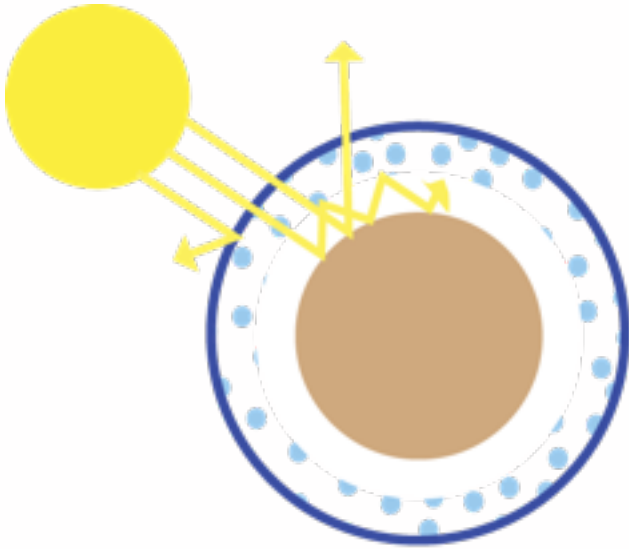
# Report out . . .

---

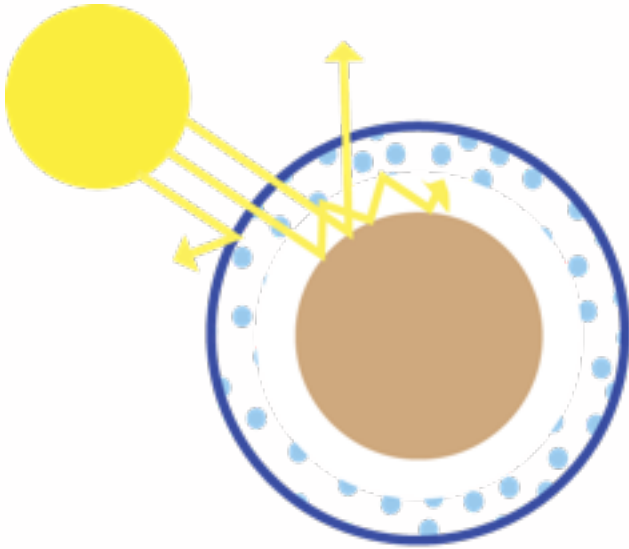
Did the models help you to reason with the problem?  
What were some of the challenges?

# Visual Models

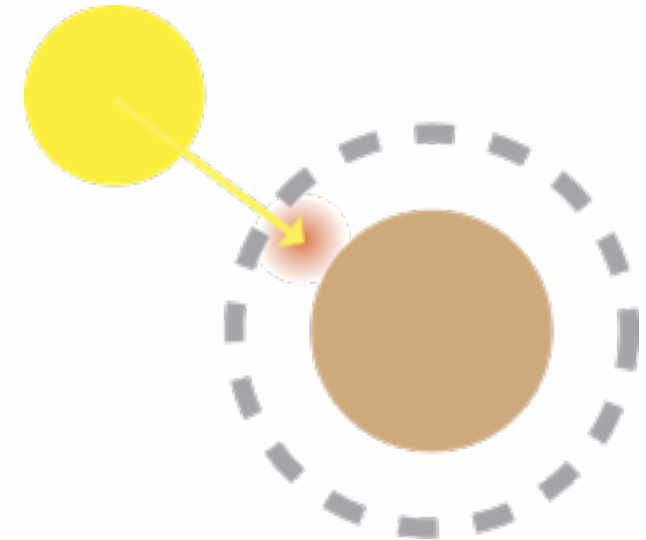
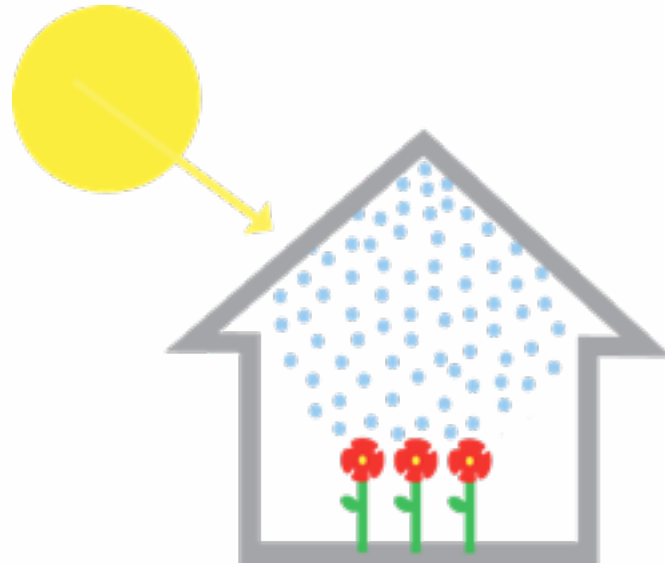
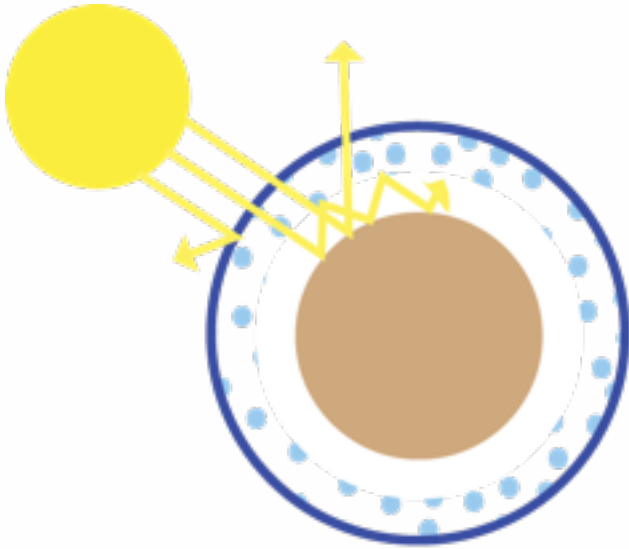
# Visual Models



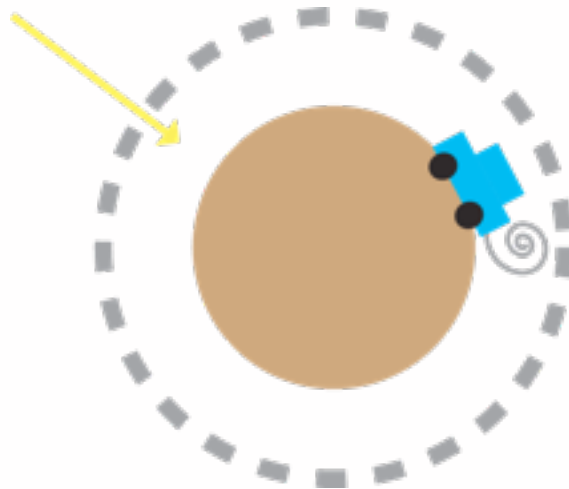
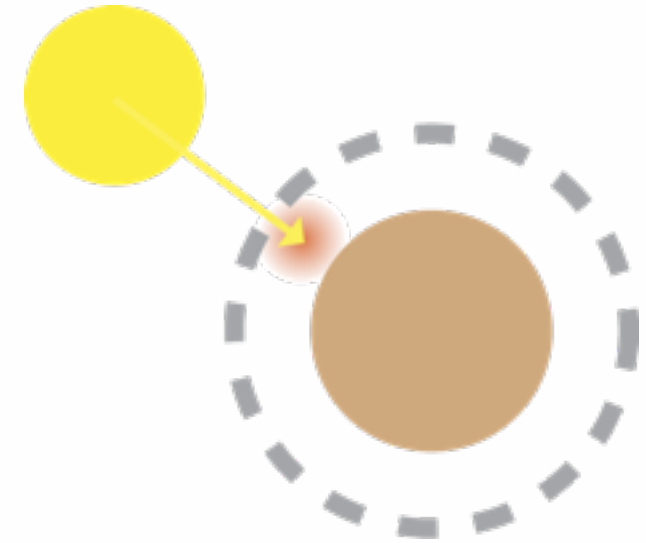
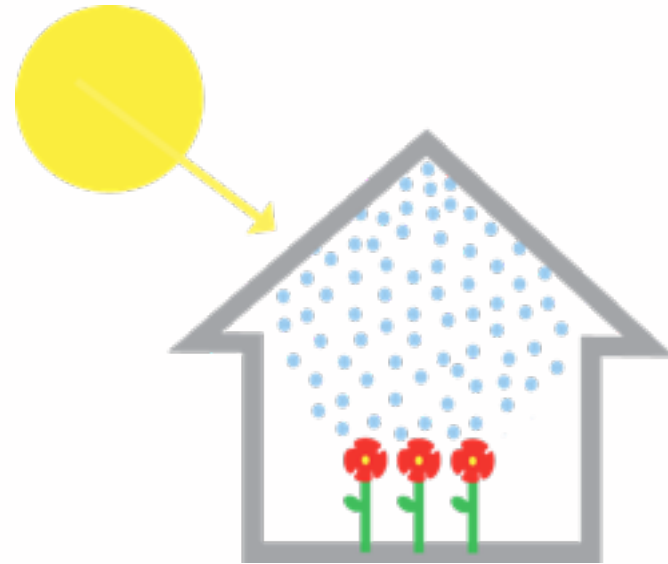
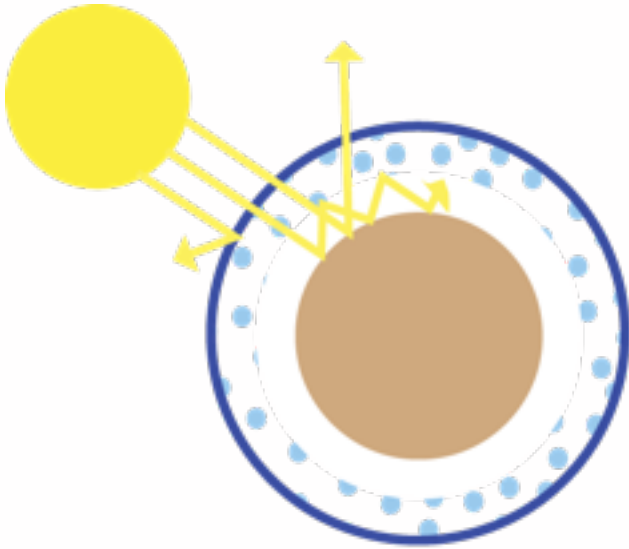
# Visual Models



# Visual Models

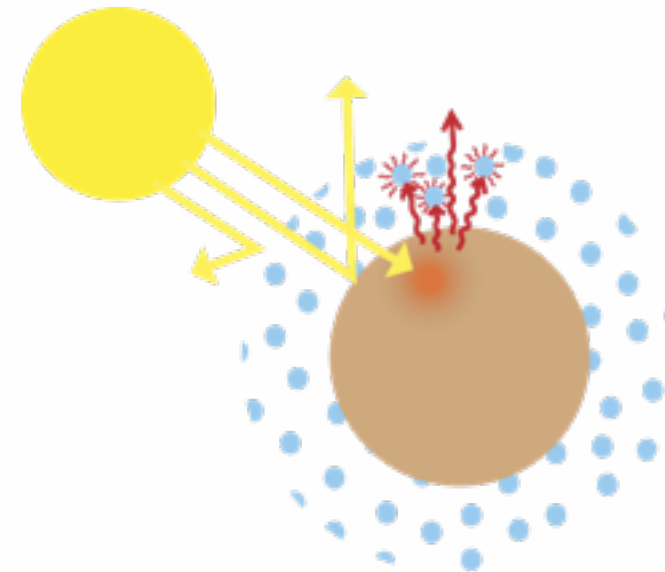
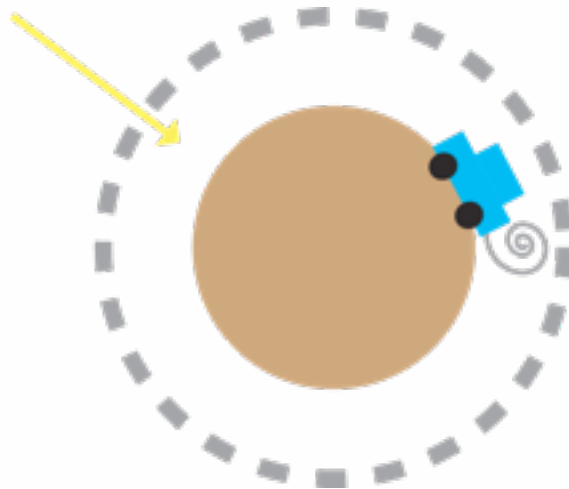
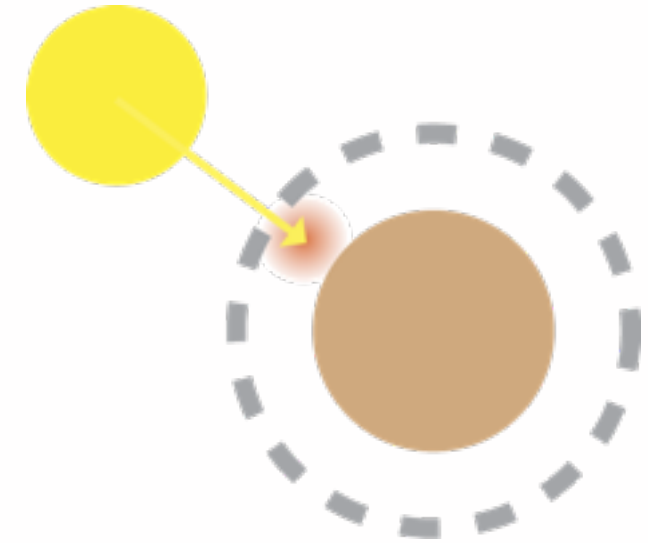
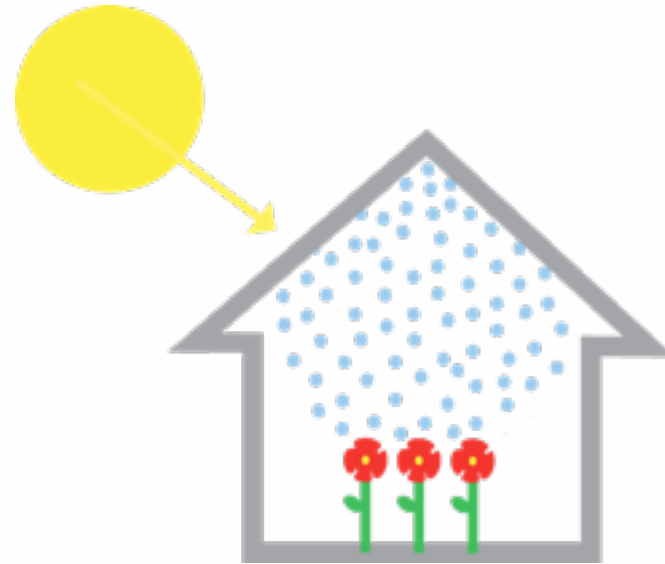
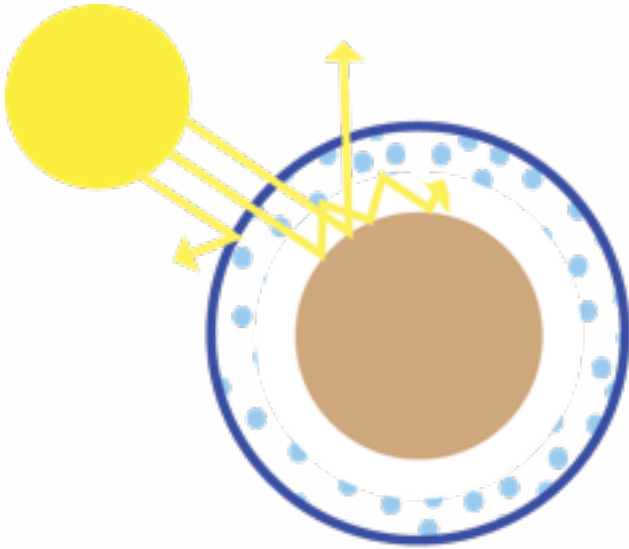


# Visual Models

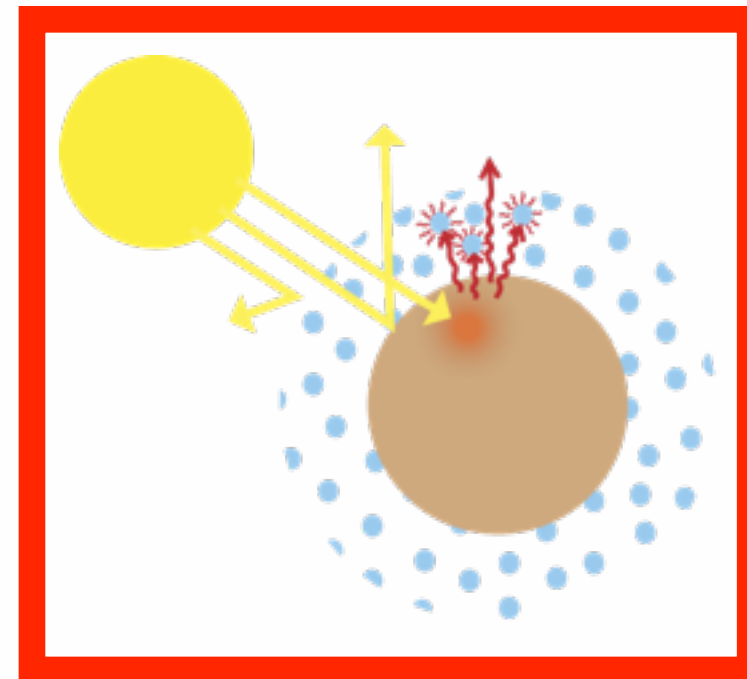
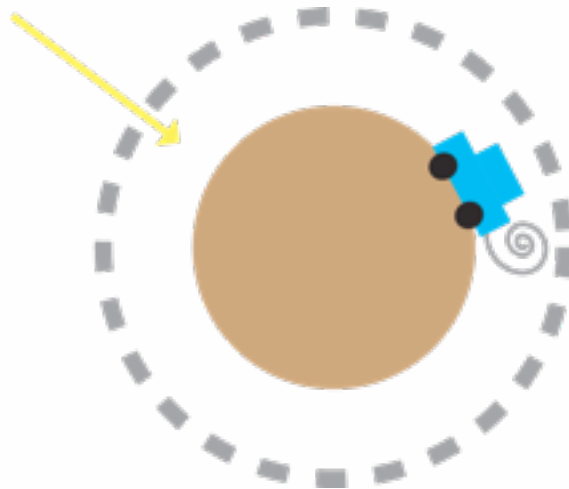
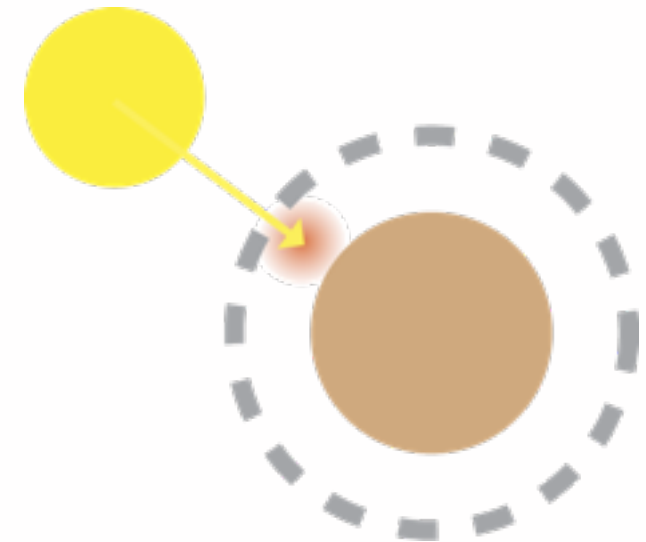
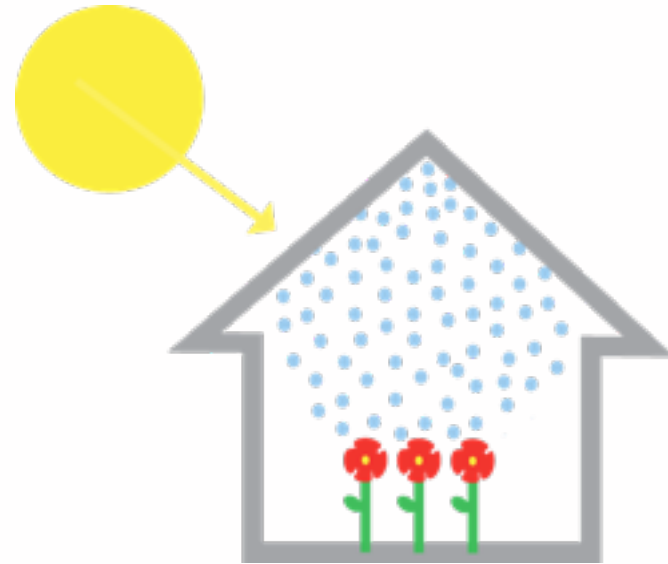
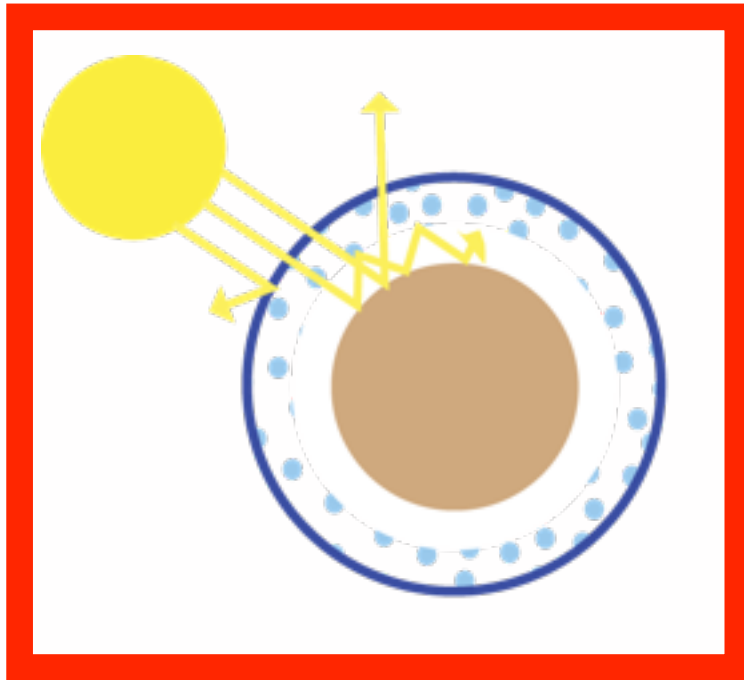




# Visual Models



# Visual Models



# Interventions to Improve Visual Model-Based Reasoning

---

# Interventions to Improve Visual Model-Based Reasoning

---

1. Affect
2. Visual literacy
3. Model-based reasoning

**Affect:**

---

**Affect:** Explain importance and assuage fears

---

**“This is *science* class, not art class!”**

**Affect:** Explain importance and assuage fears

---

“This is science class, not art class!”

**“Oh no, I’m *terrible* at drawing”**

**Affect:** Explain importance and assuage fears

---

“This is science class, not art class!”

“Oh no, I’m terrible at drawing”

**“This is going to take a lot of *work*”**

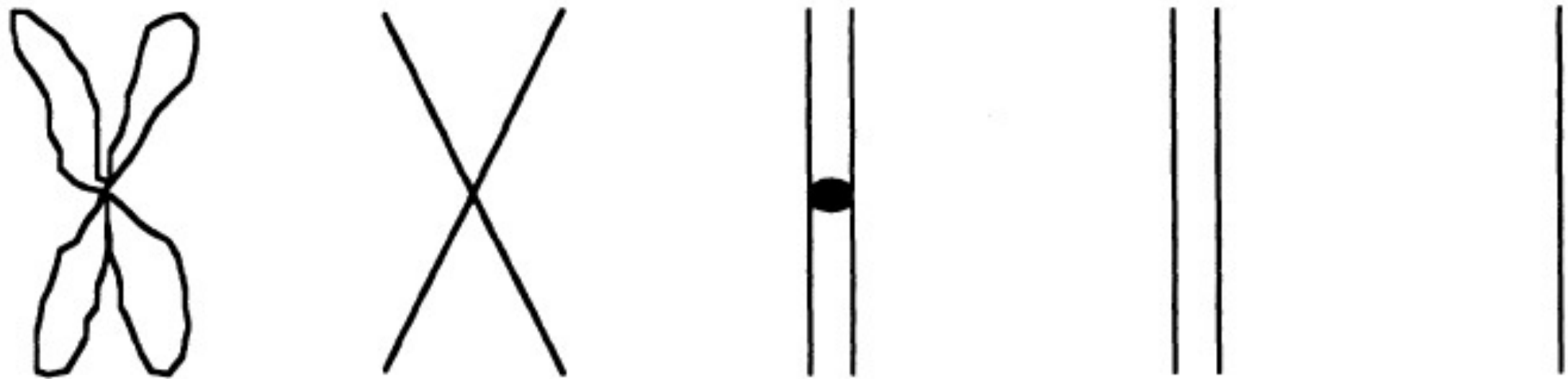


# Visual literacy

---

# Visual literacy: Define symbols explicitly

---

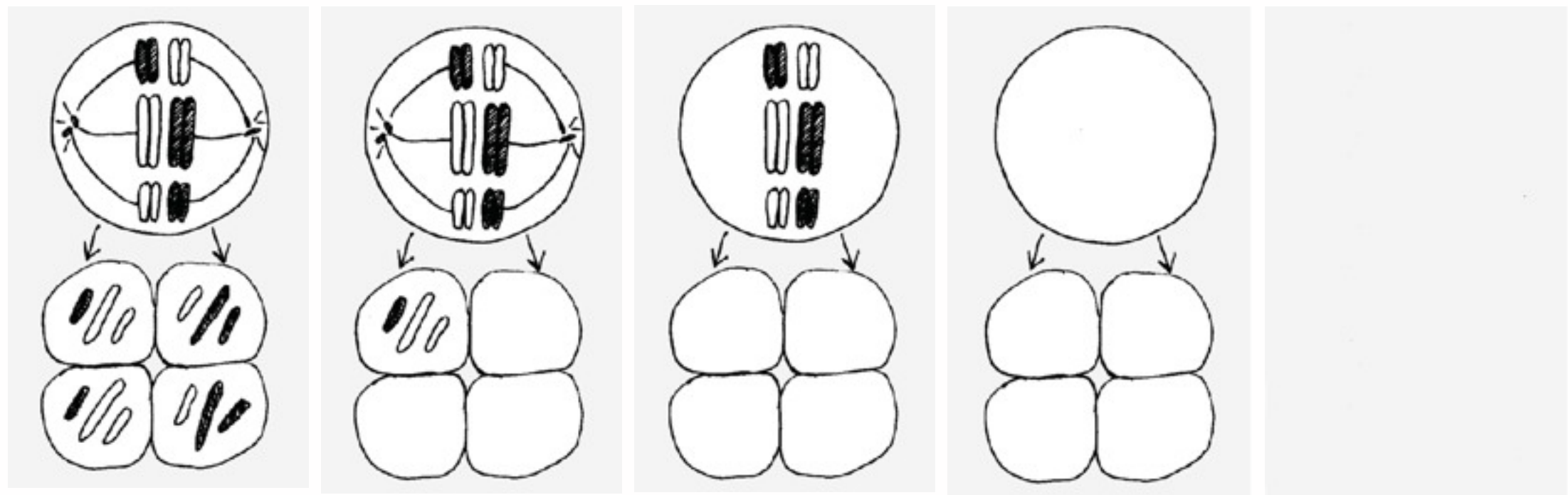


...and give students practice translating

Kindfield (1994)

# Visual literacy: Provide scaffolding

---



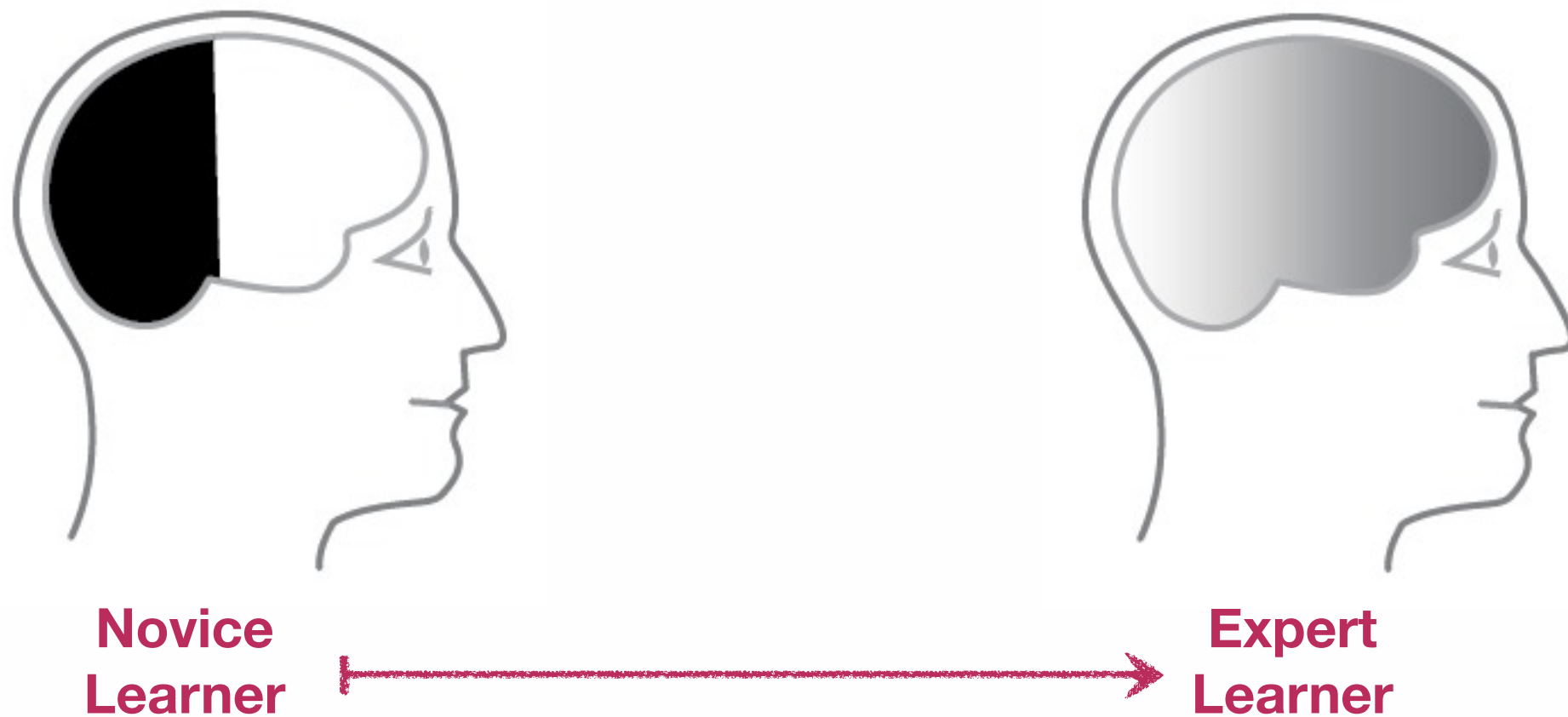
**Instructor-  
generated**  
**PASSIVE**



**Learner-  
generated**  
**ACTIVE**

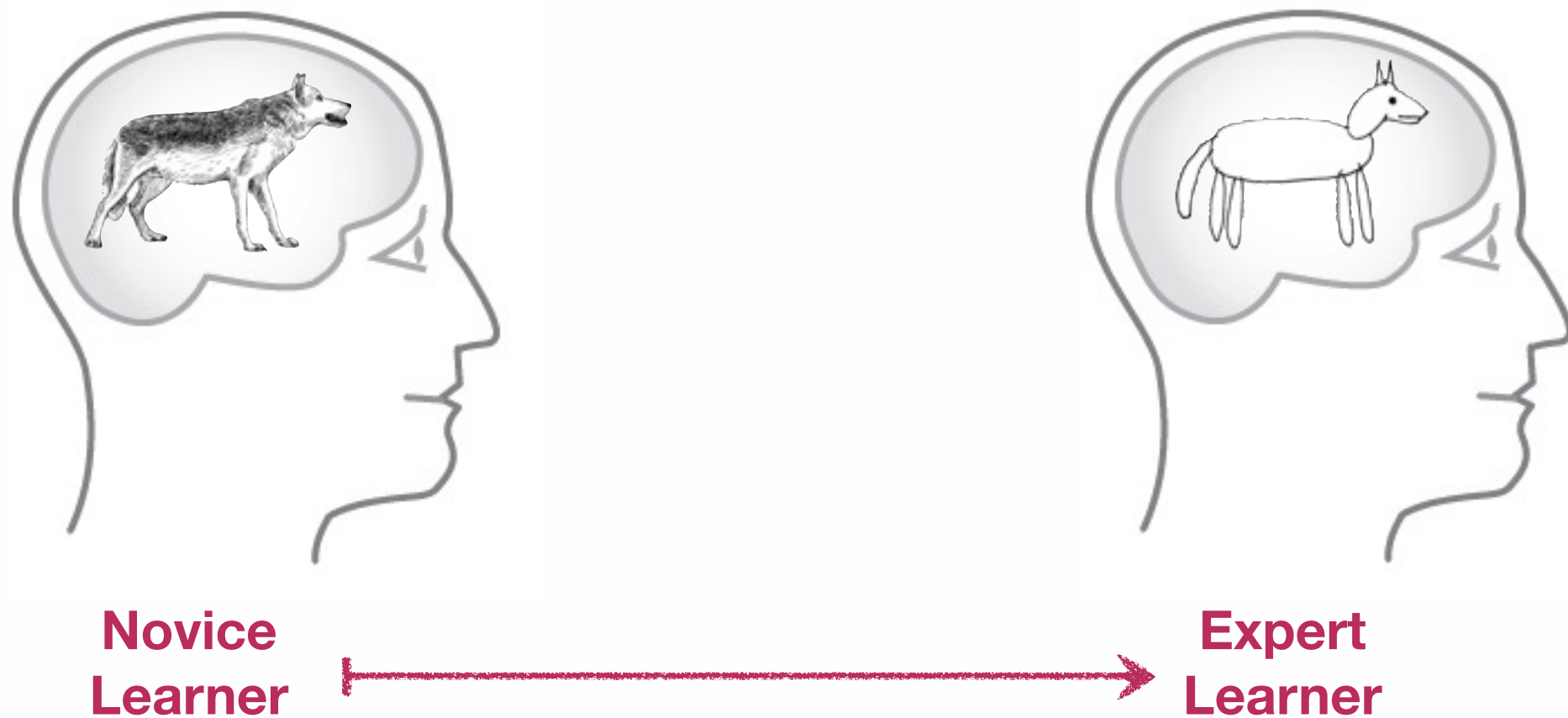
# Model-based reasoning: Provide practice

---



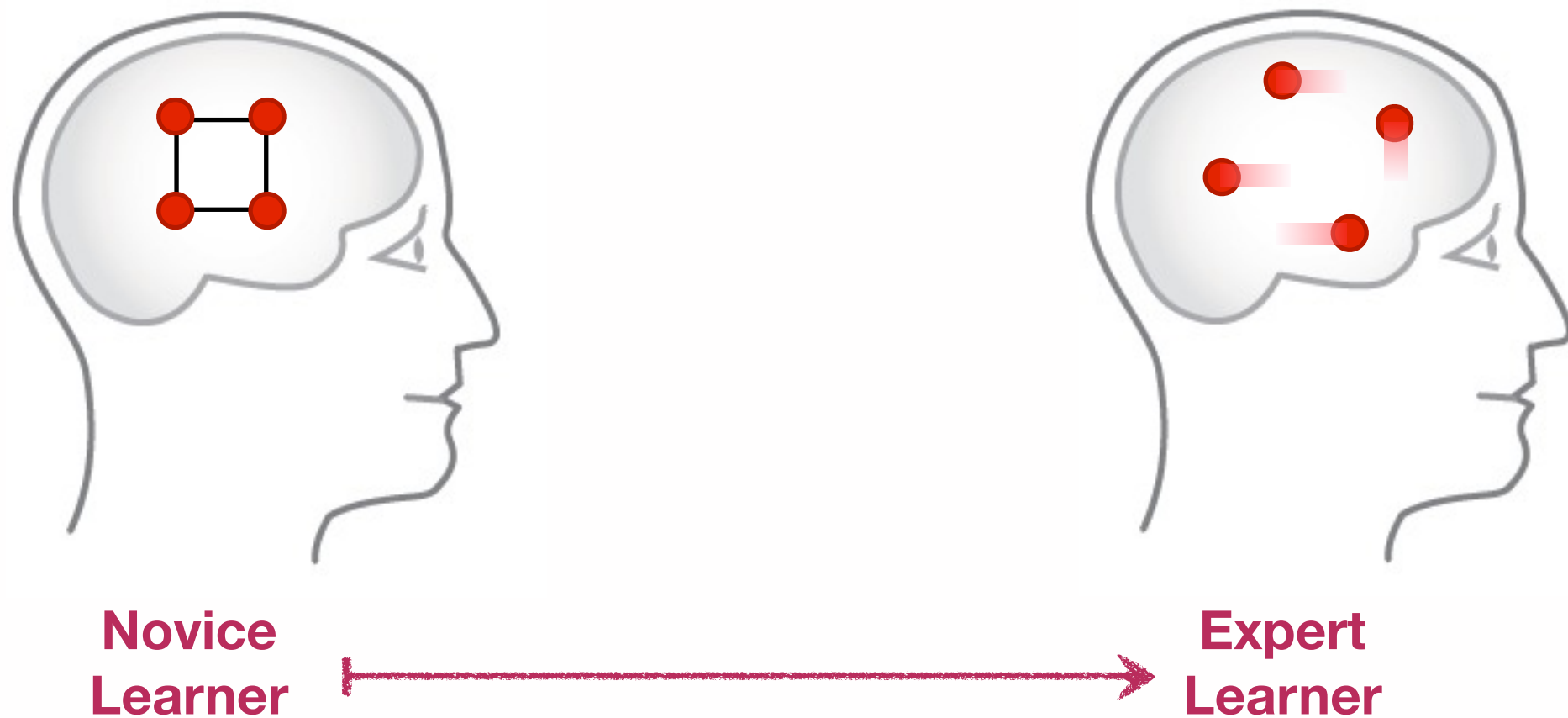
# Model-based reasoning: Provide practice

---



# Model-based reasoning: Provide practice

---



# **Evaluation:** How can we make drawings more practical to evaluate?

---

# Evaluation: Provide a key of symbols

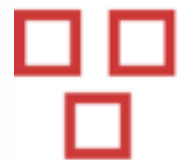
---



SUN



EARTH



ABSORBED  
ENERGY



Energy



INFRARED/  
HEAT



PLANTS



GASES



BARRIER



POLLUTION



OZONE/HOLE



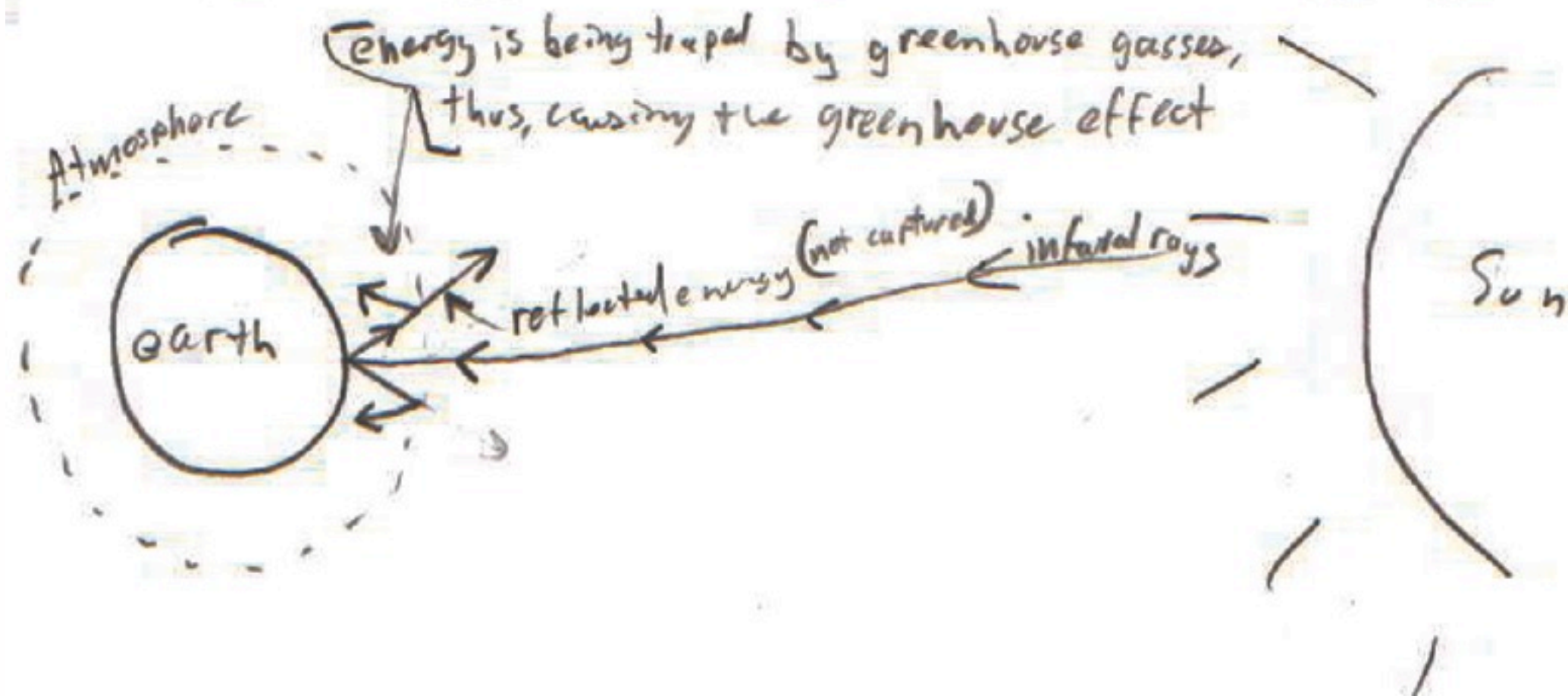
GREENHOUSE



# Evaluation: Use a grading rubric

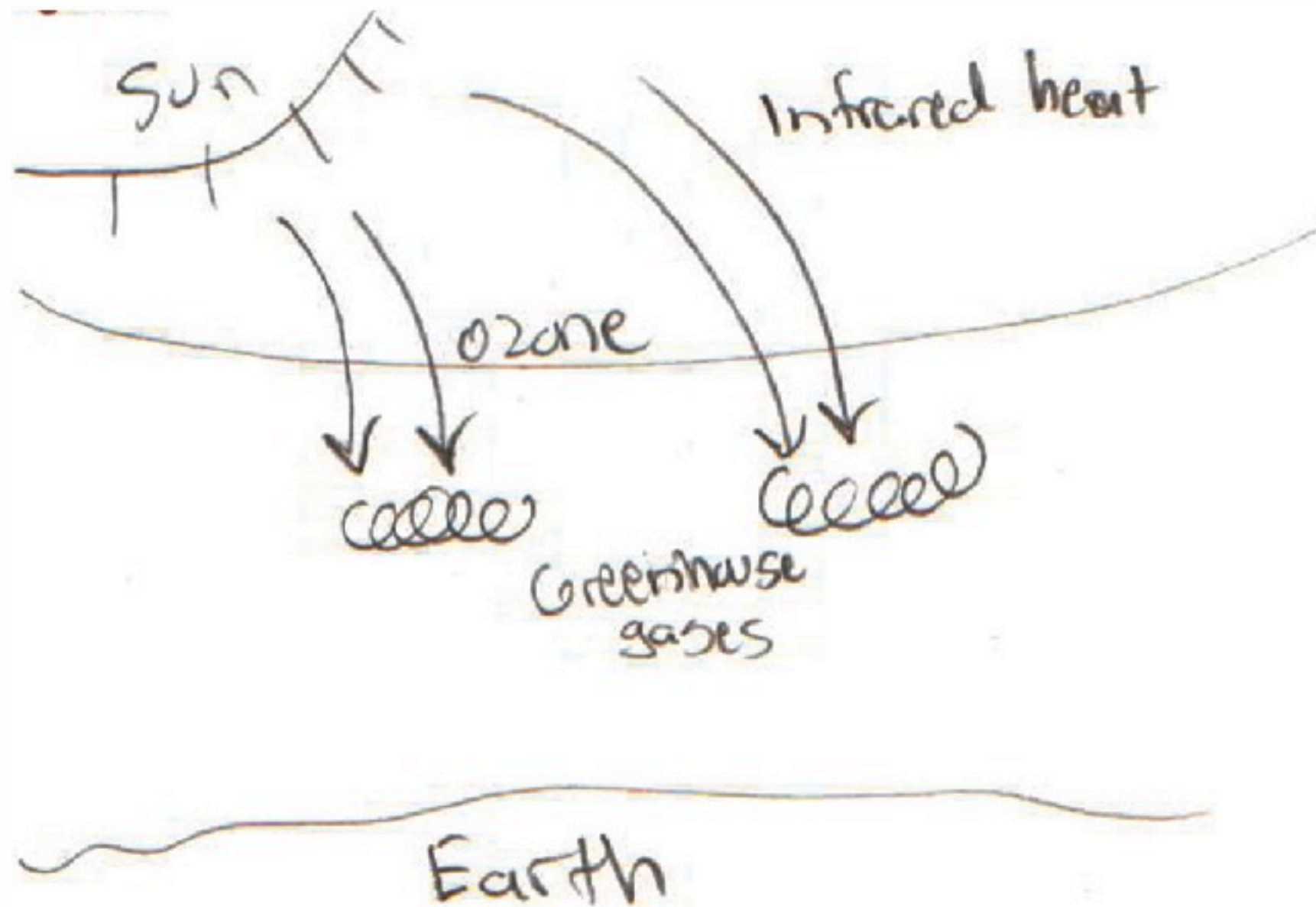
---

	Excellent	Acceptable	Needs improvement	Not present
Energy types	identifies full spectrum solar radiation and infrared	only identifies infrared	energy is represented but unlabeled	not present
Energy change	solar energy shown absorbed at the earth's surface and IR is emitted	the earth is shown emitting IR but no source of energy	energy is shown unchanged	not present
Matter types	greenhouse gases are labeled and shown distributed above the earth	greenhouse gases labeled, but represented as a barrier layer	representation incorporates concepts of ozone or holes	not present
Matter change	greenhouse gases are labeled and shown absorbing and emitting IR	gases are shown absorbing and emitting energy	gases are shown reflecting energy	not present



When the sun emits infrared radiation, it passes through the atmosphere unabsorbed and is reflected off the surface of the earth. Some of it escapes into space but the majority of it gets trapped in the atmosphere by greenhouse gases thus causing the greenhouse effect.

# Evaluation: Prompt students to write a caption



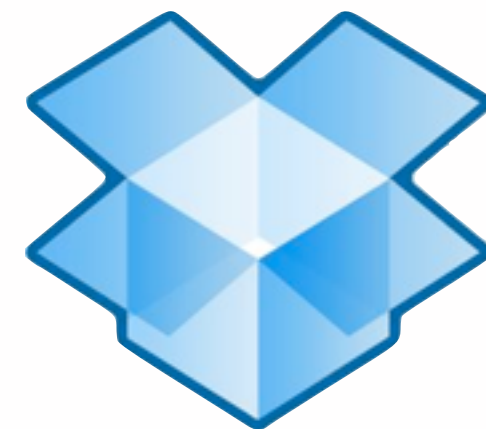
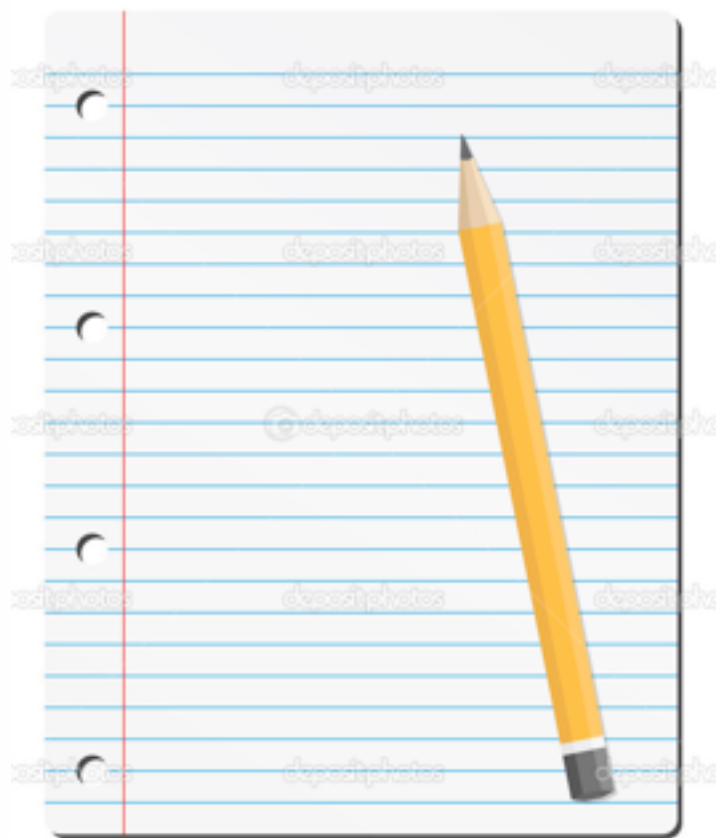
In this figure, you can see the gases capture infrared heat from the sun.

# **Evaluation:** Digital drawing resources

---

# Evaluation: Digital drawing resources

---



Discussion Forum

# **Evaluation:** How can we make drawings more practical to evaluate?

---

- Sampling
  - Going over one student's model
  - Peer evaluated (groups or individuals)
- Easing grading strains
  - Rubrics
  - Keys
  - Captioning (Diane Ebert-May, Tammy Long)
  - Follow-up clicker question (John Merrill)

# In conclusion

---

# In conclusion

---

**Drawing is a science process skill (science as way of knowing)**



# In conclusion

---

Drawing is a science process skill

**As with other skills, students benefit by**

# In conclusion

---

Drawing is a science process skill

**As with other skills, students benefit by explicit instruction**

# In conclusion

---

Drawing is a science process skill

**As with other skills, students benefit by explicit instruction and practice, practice, practice.**

# In conclusion

---

Drawing is a science process skill

As with other skills, students benefit by explicit instruction and practice, practice, practice.

**There are a lot of techniques and resources to make drawings easier to use in the classroom**



---

Any Questions?



# One-Minute Paper

---

- What will you incorporate next week in class?
- What is a barrier to you incorporating this type of approach?

# Handout

---

- Digital resources
- Why should students draw
- Sample rubric
- Survey samples of practices